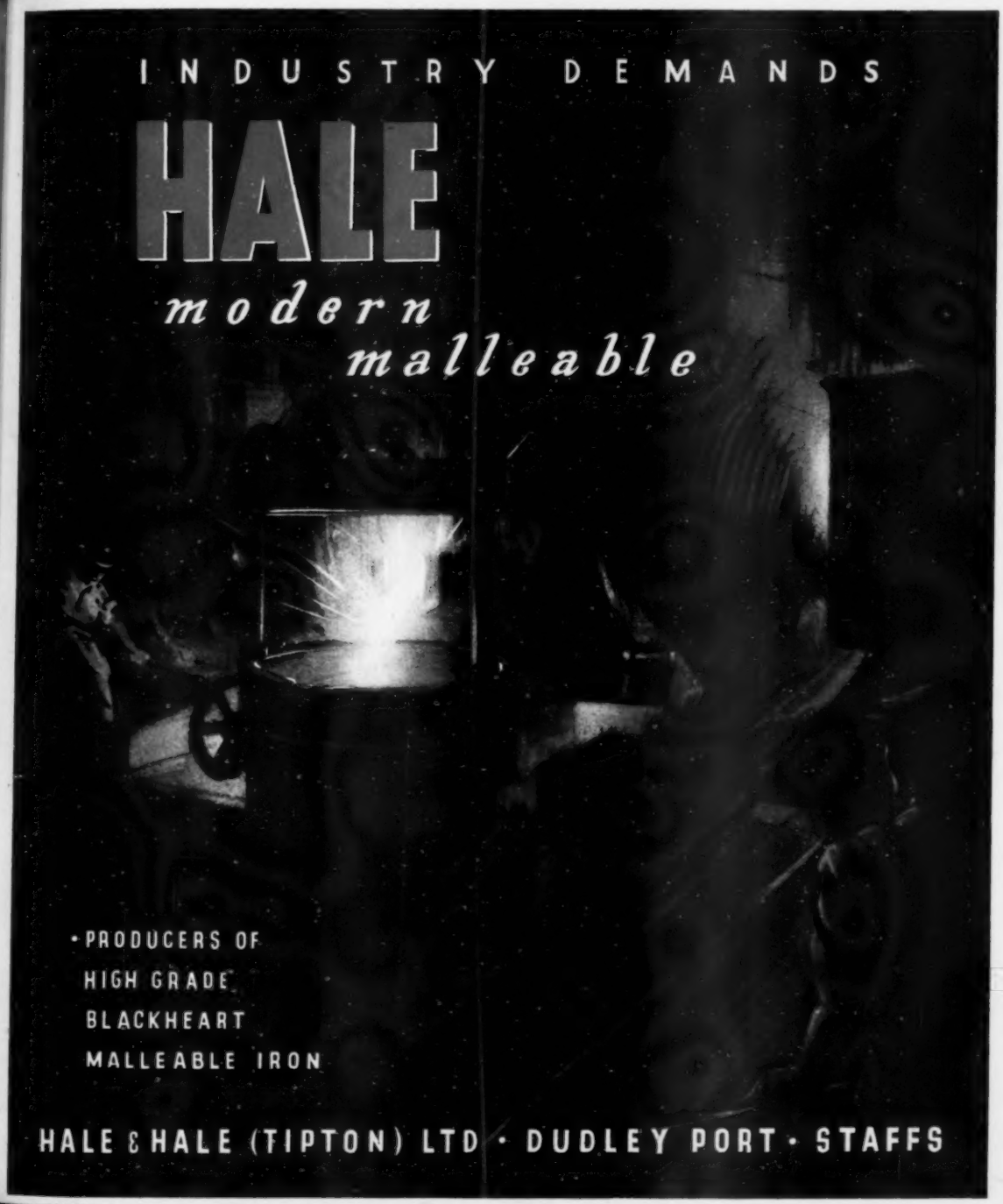
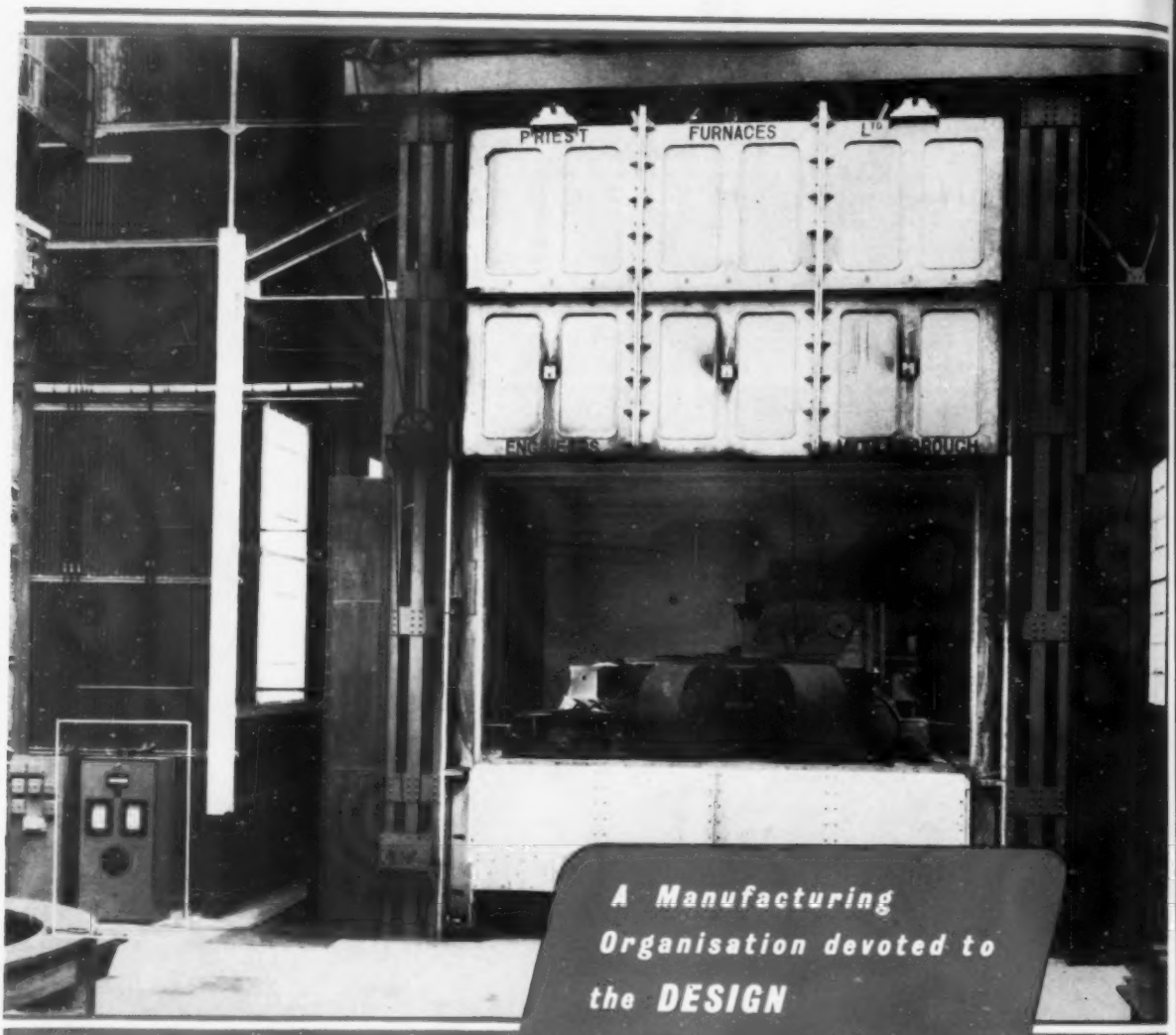
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THE BRITISH JOURNAL OF METALS

Vol. 47 No. 282 APRIL, 1953 27 APR 1953 Monthly: TWO SHILLINGS





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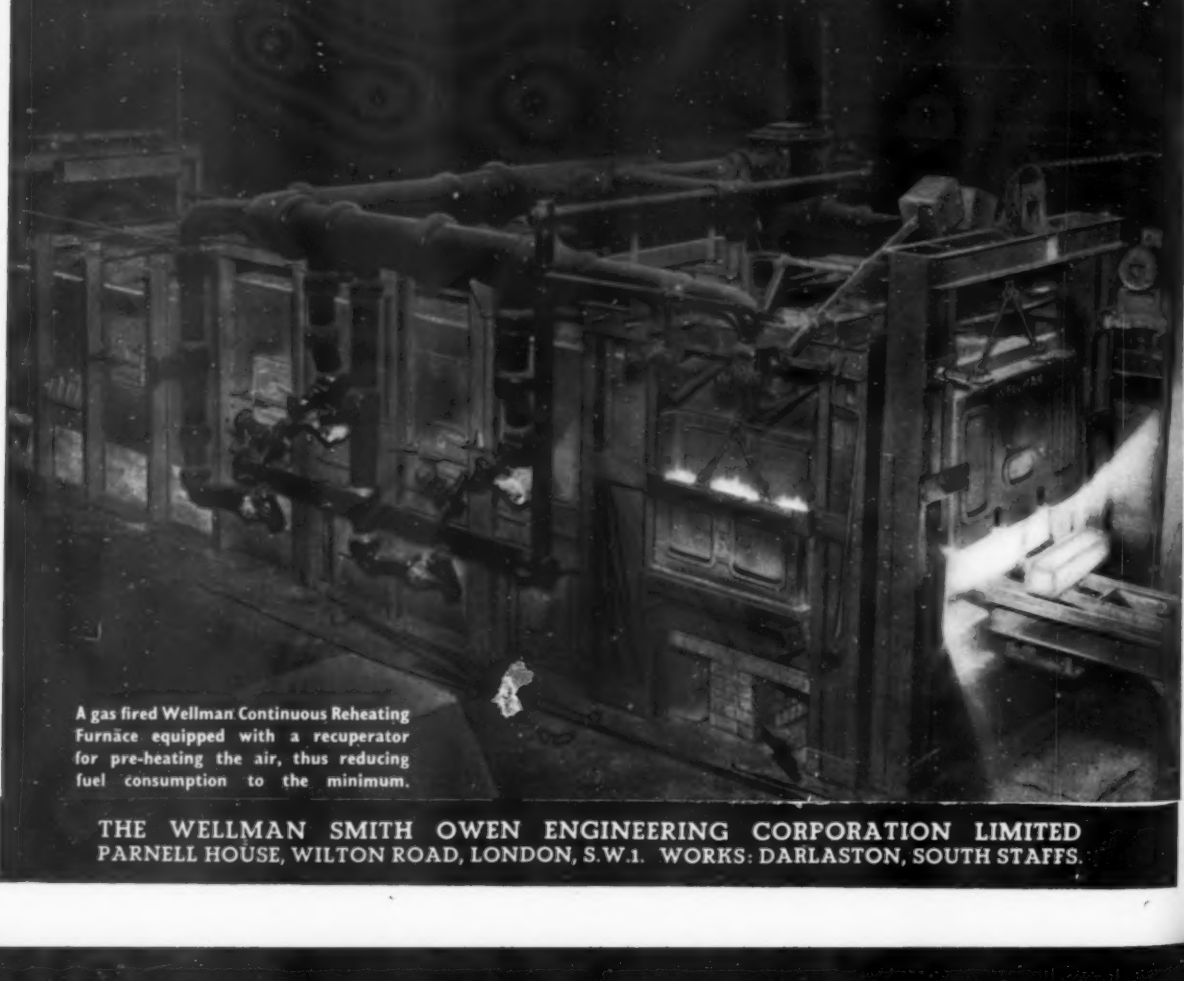
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METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

APRIL, 1953 Vol. XLVII. No. 282

The British Industries Fair

DURING the last few years, the British Industries Fair has become almost as much of a fixture as Christmas Day, and more of one than Easter Monday, with its dependence on the phases of the moon. One has come to count on the B.I.F. commencing on the last Monday in April or the first in May, and although each year has revived discussion on its advantages and disadvantages, there has never seemed to be much solid backing for the suggestion that it should be discontinued, or at least should not be held so frequently. This year there were rumours that the Coronation Fair was to be the last—that there would be no Fair in 1954—and so strong were these rumours that it was felt necessary for the Board of Trade to issue an official denial, and to stress that, immediately the Coronation Fair is over, work will begin on the arrangements for the 1954 Fair which is to be held in Birmingham and London, as usual. There is an old saying, however, that there is no smoke without fire, and there certainly does seem a tendency for criticism of the Fair to increase. On the other hand, the Exhibitions Advisory Committee, which is studying the long-term question of the best way to organise the Fair, has already informed the Board of Trade of its unanimous opinion that it should continue.

It must not be forgotten that the Fair cannot exist apart from its exhibitors, and the fact that it has continued annually since its inception in 1915—apart from a lapse in 1925 when the Empire Exhibition was held at Wembley, and a seven year gap caused by World War II—shows that it has had substantial backing from industry as a whole. One has only to glance through the catalogues for the post-war years to see the large number of instances where the same firms occupy the same stands year after year. It is true that after the war the demand for stands exceeded the space available, so that relinquishing one's claim on a stand was a matter which called for serious consideration, in view of the fact that, having left, the chances of getting back were extremely small.

This year, however, there appear to be signs that the demand for space is slackening off, and one searches the catalogue in vain for several firms who have, for the past few years at least, been "ever-presents." Moreover, one or two firms, in describing their stands, refer to the fact that they have more space than last year owing to the adjacent stand being vacated. It is rather difficult to analyse the reasons for these withdrawals, just as it is difficult to explain why one firm considers participation essential, whereas a competitor with an almost identical field of interest does not.

To the individual company, it matters little whether it sells its goods at home or abroad, other things being equal, but in the national interest exports must be fostered to help pay for our imports of food and raw materials. It is as a means of increasing our overseas trade that the B.I.F. has been developed, particularly in recent years, and the annually increasing number of foreign buyers who have visited it testifies to the success which has attended the efforts in this direction. An exhibition of this type probably has its greatest value at times when a seller's market prevails, and it will be interesting to see how the 1953 attendance figures for overseas visitors compare with those for recent Fairs, although the possibility of the Coronation influencing this year's figures should not be overlooked. It seems, however, that in to-day's conditions something more than a shop window is required and mere representation at a national or international exhibition is not enough. An energetic selling policy is called for, and although exhibiting at trade fairs may be an integral part of such policy, its role, relative to direct salesmanship, is less important, particularly in the case of home-based exhibitions, than was formerly the case.

Assuming that industrial exhibitions serve a useful purpose—and the foregoing considerations do not refute such an assumption—the frequency with which they are held is a point of some importance. The view has often been expressed that the B.I.F., with its once a year showing, is held too frequently. One section of the engineering industry which feels strongly in this matter is the machine tool manufacturing group, which holds its own exhibition in London every four years. A similar interval passes between successive exhibitions of textile machinery in Manchester, whilst the Engineering and Marine Exhibition is held biennially. It has also been said that there are too many exhibitions, and whilst it may be felt that some of these exhibitions have not the international standing of the B.I.F.—certainly they are not government sponsored—they are, in most cases, more representative of the industry concerned. One of the features of the present arrangements is that every two years there are two major general engineering exhibitions, which results in a division of effort for exhibitors, and a division of interest for buyers.

One of the disadvantages of an annual engineering exhibition, from the point of view of the regular visitor, is that there are bound to be many stands showing "the mixture as before." Many exhibitors, of course, participate for reasons of prestige, rather than to introduce new lines, and for them the stand offers an opportunity for the renewal of old acquaintanceships, and for the discussion of customers' problems. For them the frequency of the Fair is not a matter of great moment but there is little doubt that a hall full of prestige stands would attract very few buyers. It is the new developments on show for the first time that instil life into an exhibition, and one would expect that a biennial Fair would carry more new exhibits, and would, therefore, present a greater attraction for visitors. Perhaps a biennial B.I.F. alternating with the Engineering and Marine Exhibition would provide a satisfactory solution to the question.

Metal Bonding for Aircraft

At a recent Press conference, Dr. N. A. de Bruyne (Managing Director of Aero Research, Ltd.) gave his impressions of an extensive tour of U.S. aircraft production centres. In opening his talk, Dr. de Bruyne pointed out that the coming of the jet engine, with the enormous fuel load it required, had forced the aircraft designer to use new methods of construction, riveted structures being on the way out. In America, progress had been made in the production of integral skin and stringer panels by machining from the solid, removing 60% or so of the metal in the process: other experiments had been made with casting magnesium alloy stringer-skin panels. In this country, development had taken place along different lines, adhesive bonding being used for metal aircraft. To illustrate the importance of adhesive bonding in weight reduction, the speaker pointed out that, in the case of the Comet Mark I, increasing the ratio of empty weight to loaded weight from 45% to 48% (maintaining the same pay load) would increase the initial cost of the machine by £175,000 and its operating costs by close on £1 million a year. Apart from weight saving, adhesive bonding also simplifies pressurisation and enables smooth surfaces to be obtained. Furthermore, fatigue strength is increased and production costs lowered.

In conclusion, Dr. de Bruyne observed that the use of adhesive bonding in Britain was much more bold and imaginative than anything he had seen in U.S.A., possibly due to the fact that the hard economic facts of jet transport had not yet struck them. On the other hand, he had seen metal honeycomb constructions in pilotless aircraft which appeared to be superior to anything done in this country. In general, although the superior technical qualities of British aircraft were freely admitted, the Americans were convinced that in their production methods they were far ahead of us. Some of their bonding techniques were very ingenious, involving novel methods of applying pressure, and of ensuring smooth surfaces.

Conference on Tinplate

For some time now the desire for a British Standard for Tinplate has been growing and there have been an interesting number of expressions of this need. These are, of course, not new: the first discussions took place at the outbreak of the 1939–45 war. A draft specification was prepared but the shortage of tinplate and other factors made the issue of a British Standard undesirable.

The question was again discussed in 1945 when the tinplate industry had just commenced a major reorganisation which would take some time to complete. It was, therefore, decided to defer action and to re-open discussions at a later date. The reorganisation of the tinplate industry, although not complete, is now well advanced and the tinplate users felt that, with the removal of the statutory controls on the use of tinplate, the time had come for positive action to be taken in the preparation of a British Standard.

Recently the industry's need for a standard was expressed in the form of formal requests from the Ministry of Supply and from the British Tin Box Manufacturers' Federation that the discussions which had been deferred in 1945 should again be re-opened. In consequence of this a conference was held recently under the ægis of the British Standards Institution. The conference was attended by representatives of the British Tin Box Manufacturers Federation, the Ministry of Supply, Board of Trade, British Iron and Steel Federation and the Tinplate Conference (tinplate producers). In addition, there were representatives from the British Closure Manufacturers Association, the Association of Steel Drum Manufacturers, the British Toy Manufacturers Association, the oil companies and other organisations concerned with the use and manufacture of tinplate. Mr. John Ryan (Chairman of the B.S.I.) took the chair at the conference.

The users stressed the importance of reducing wastage which resulted from faulty material and the need for greater accuracies in manufacture. The tin box manufacturers emphasised particularly the need to increase manufacturing speeds and to improve the accuracy of their products in order to meet the canners requirements for increases in canning speeds. It was argued that these increases and improvements could only be obtained by the supply of satisfactory tinplate, and it was therefore necessary that generally recognised standards should be drawn up. The packaging of tinplate was also regarded as being an aspect that would need to be given careful consideration as present practice was often below a satisfactory standard. One important point made was that a satisfactory increase in canning speeds would be equivalent to the opening of a new canning plant.

The representatives of the tinplate industry pointed out that although the reorganisation of the industry had made considerable advances it was not yet complete and some time must elapse before it could be complete. The conference decided however, that the machinery for the preparation of a British Standard should be set in motion without delay, it being appreciated that it would necessarily take some time before the standard would be ready for publication, and it was hoped that by then the re-organisation of the tinplate industry would be such that it would be possible to implement the requirements of the standard to the satisfaction of all parties.

Executive Training Methods

American methods of training the executives and administrators of the future are being examined as an aid to increasing productivity in the United Kingdom and Western European countries. The study is being made by Mr. R. A. L. Pears, of the Administrative Staff College, Henley-on-Thames, under the sponsorship of the Mutual Security Agency's productivity and technical assistance programme. The college, multi-national in character, offers advanced training to men and women with executive ability in industry, commerce, trade unions and public service.

In addition to its executive training courses, the college is called upon by a steadily increasing number of business firms in Western Europe and Britain for advice on general policies of in-plant training of executives. It is believed that Mr. Pears observation of American practices in the field of executive development will be helpful in this industrial advisory work, as well as in the college's student selection programme.

Change of Address

The Coventry Office of Edgar Vaughan and Co. Ltd., the oil specialists of Birmingham, has been transferred to 23, Eaton Road, Coventry.

The Hard Carbides: Their Properties and Application to the Production of Sintered Hard Metal

By A. G. Gardner,* A.I.M.

After discussing the properties of the carbides used in the production of sintered hard metal, the author proceeds to a description of the manufacturing processes and the control necessary to ensure a consistently satisfactory product. In conclusion he discusses the cemented carbides used for cutting tools.

THE hard carbides consist chiefly of the carbides of metals from Groups IV, V and VI of the Periodic Table, namely, titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum and tungsten, and because they have high melting points, they are difficult to prepare in the pure state. They are extremely hard and possess the metallic properties of lustre and high thermal conductivity to a marked degree. Alloys are formed by these carbides in two ways:

(1) with metals—particularly of the iron group; and

(2) with each other—forming solid solutions.

The usual rules of valency are not obeyed by the hard carbides, which exist in the main as interstitial compounds, being formed from the ordinary metallic lattice by the insertion of the relatively small carbon atoms in the interstices. The energy required to fill the lattice completely is high and it is, consequently, difficult to obtain the exact stoichiometric compound: the carbides can thus have a range of composition, and can be considered as solutions of carbon in the respective metals. Whilst cemented carbides have hardness values ranging between 1,000 and 2,000 V.P.N., the pure carbides are much harder; tungsten carbide, for example, has a hardness of 2,200 V.P.N. The carbides of vanadium, titanium, zirconium, chromium and molybdenum are relatively soft, whilst those of tantalum, niobium and tungsten are relatively hard. In this connection, it is interesting to note that silicon and boron carbides are harder than any of the metallic carbides.

Mention has been made of the high melting points of the carbides, and it will be seen from the figures given in Table I that in most cases they are too high for melting and casting to be contemplated.

TABLE I.—MELTING POINTS OF THE HARD CARBIDES.

Carbide	M.P.—° C.	Carbide	M.P.—° C.	Carbide	M.P.—° C.
Cr_3C_2	1,890	VC	2,830	ZrC	3,530
Mo_2C	2,690	TiC	3,150	TaC	3,880
W_2C*	2,750	NbC	3,500	HfC	3,890

* WC decomposes at 2,600° C.

Carbides used in Hard Metal Manufacture

Di-Tungsten Carbide (W_2C).—This material can be prepared by heating a mixture of carbon and tungsten powders, in stoichiometric proportions, between 1,000° C. and 1,600° C. in an atmosphere free from carbon, care being taken to avoid carburisation or decarburisation of the final product.

The specific gravity is 17·15.

Tungsten Carbide (*WC*).—A similar method can be used for the preparation of this carbide, except that air must be excluded and a slightly carburising atmosphere maintained. Tungsten carbide can also be prepared by reducing tungstic oxide directly to carbide by means of carbon at 1,000°–1,500° C. in an iron tube: the product has a definite carbon content and is free from oxide. In a third method, tungsten metal is carburised directly at high temperatures by means of carbon monoxide, methane or other hydrocarbons, control being exercised by varying the temperature and partial pressure of the carburising gas.

The specific gravity is 15·6.

Titanium Carbide (*TiC*).—This carbide can be prepared by heating in an atmosphere of hydrogen in a carbon tube furnace, a mixture of titanium dioxide and 15–20% less carbon than is theoretically required, the deficiency being supplied by the hydrocarbons formed in the tube. The product is finally heated for a quarter of an hour at between 2,500° C. and 3,000° C. Titanium carbide is not so readily formed as tungsten carbide and it is difficult to obtain a value for the carbon content approaching the theoretical.

The specific gravity is 4·25.

Tantalum Carbide (*TaC*).—The usual method of preparation consists of heating a mixture of tantalum pentoxide and carbon in hydrogen at 1,600° C. This yields a carbide of specific gravity approximately 14·05. There is another method for the production of tantalum and other carbides which may be used. In this, tantalum powder and graphite are added to molten nickel at a temperature in the region of 2,000° C. The mass is cooled and the nickel dissolved out, leaving crystalline carbide of almost theoretical composition and specific gravity, 14·48.

Other Carbides.—On occasion other carbides, such as those of vanadium, niobium and chromium, are also used.

The Tungsten-Carbon System

Tungsten carbide forms the basis of most sintered hard metals and it is appropriate to refer to the tungsten-carbon system at this point. The equilibrium diagram according to Sykes is reproduced in Fig. 1. No higher figure than 0·12% has been recorded for solubility of

* Research Metallurgist, Wickman, Ltd., Coventry.

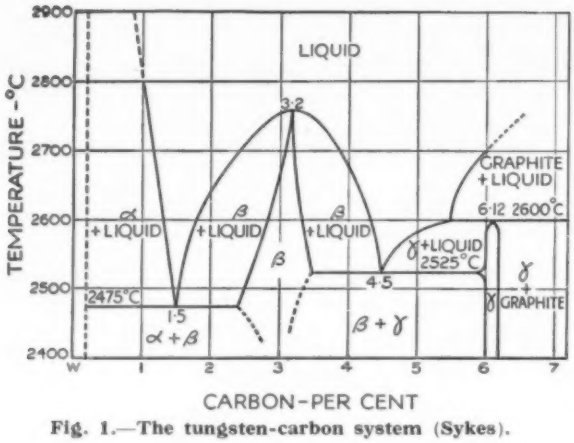


Fig. 1.—The tungsten-carbon system (Sykes).

carbon in tungsten, and although Sykes' diagram indicates some solubility of carbon in tungsten carbide, this is at present still rather doubtful. W_2C and WC are apparently the only two carbides, the former existing in two forms: α-W_2C stable up to 2,400° C.; and β-W_2C stable above this temperature. When carburising tungsten from the gas phase, the required concentration of methane in hydrogen increases with rising temperature. At minimum concentration, WC separates up to 1,900° C.; α-W_2C from 1,900° C. to 2,400° C.; and β-W_2C above 2,400° C.

Difficulties were experienced by Sykes due to rapid absorption of carbon from the crucible and the gaseous atmosphere. The diagram shows a first eutectic, comprising tungsten and W_2C and containing approximately 1·5% carbon: this eutectic melts at about 2,475° C. The second eutectic consists of W_2C and WC, contains about 4·5% carbon and melts at 2,525°C., approximately. Finally, the WC phase decomposes at 2,600° C., yielding a tungsten-rich liquid and graphite.

The Production of Sintered Carbides

In the production of cemented carbides, powdered materials consisting of one or more metallic carbides and a lower melting point cementing or bonding material are mixed together. The carbides in general use are those of tungsten, tantalum and titanium, whilst cobalt and nickel, usually the former, are the most common bonding agents. Cemented tungsten carbide with cobalt as the binder is the most usual combination.

The carbide powder and bonding metal are produced in a fine state of sub-division, the average size of the carbide particles being between one and five microns. Thorough mixing of the two powders is effected by a ball-milling operation which may take up to 60 hours to complete. The resultant mixture is pressed into the required shapes and these fragile compacts are given a pre-sintering treatment. This consists of heating to 800–900° C. for about an hour, during which time partial sintering takes place. After pre-sintering, the pieces are of similar strength to chalk and may be handled and cut to shape. Final sintering is carried out by heating for about half-an-hour in an atmosphere of pure dry hydrogen, at a temperature between approximately 1,350° C. and 1,600° C., depending on the content of cobalt or other bonding metal. Melting of the bond and considerable contraction occur, and a dense material is obtained which consists essentially of carbide grains set in smaller amounts of bonding metal. Typical structures can be seen in the photomicrographs shown in Figs. 6, 7, 10 and 11.

The main operations may, therefore, be dealt with under the following headings: (1) mixing of components; (2) pressing of compacts; (3) pre-sintering; and (4) sintering.

1.—Mixing of Components

Very fine particle size powders are used—usually below 10 microns. Carburising of tungsten powder often produces a smaller average grain size than the original powder. The bonding metals (usually cobalt and sometimes nickel) are usually obtained by hydrogen-reduction of the oxides.

The milling of carbide compositions has a dual purpose: grinding of the carbide powder, and intimate mixing and coating of the bonding metal on the carbide grains. Steel mills are preferred to porcelain ones, as contamination by silica is more harmful than that by iron, and milling is usually carried out wet in order to minimise oxidation. If the bonding metal is much coarser than the powdered carbide, "pockets" of binder may result, leading to inefficient sintering and lower strength. Prolonged milling probably tends to disintegrate large carbide particles, whilst very fine particles agglomerate. Insufficient milling, on the other hand, results in local concentrations of bond metal and consequent weakness. The photomicrograph shown in Fig. 2 illustrates the result of insufficient milling, the local concentrations of bonding metal appearing as "lakes."

Milling should be continued until the particle size of the carbide grains is suitable, and until all the carbide grains are evenly coated with bonding metal and intimate mixing is complete. The time required is never less than 10 hours, and is usually nearer 60 hours. The period can be shortened for fine powders, but any increase in the number of constituents will increase the time of milling, and this should also be longer when less bonding metal is present. The speed of the mill should be roughly 80% of the minimum speed at which the balls are carried round in the mill without tumbling.

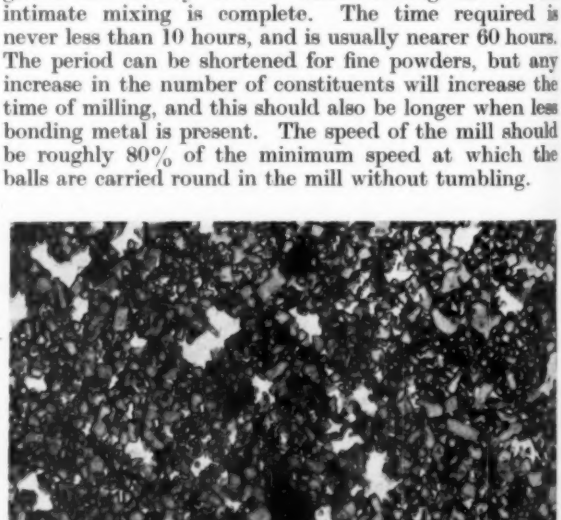


Fig. 2.—Cobalt segregation in cemented carbide (WC + 6% Co) due to insufficient milling. Etched in alkaline potassium ferricyanide. × 1,500

2.—Pressing of Powder Compacts

Apart from the consolidation of the powder into a readily handled shape, this operation aims at reducing the intergranular porosity as far as possible in order to reduce ultimate shrinkage. This factor is not, however, very important with carbides, since the powder does not readily flow and carbide particles are not deformable. It follows from this that the use of high pressures is not necessary: in fact such a procedure would produce defects. For this reason, the lowest pressure compatible with ease of handling should be used.

In a pressed powder, the density decreases with depth, and this effect is accentuated as the diameter of the piece is decreased. A lubricant is often added in order to reduce friction and give uniformity of pressure, typical examples being paraffin wax in carbon tetrachloride and camphor in petrol.

Should the powder be unevenly compressed, unequal contraction takes place, which results in warping and irregular surfaces.

Hot Pressing.—This operation is carried out at the actual sintering temperature in a hydrogen atmosphere, and combines the pressing and sintering operations. The dies are usually made of graphite, and low pressures —of the order of 1,500 lb./sq. in.—are used for two or three minutes. Sounder products are obtained compared with the cold press and sinter method, but there is a tendency for molten bonding metal to be squeezed out if it is present in excess of 6%. Grain growth is cut to a minimum and the microstructure is practically free from the regularly shaped grains which are frequently found in cold-pressed material. Nevertheless, the cold press and sinter method is the one generally adopted since it is a suitable batch method and complicated shapes can be handled.

3.—The Pre-Sintering Process

This term is applied to the heating step in the process which slightly hardens the pressed pieces so that they can be handled and shaped. The partial sintering which takes place during the hour's heating in hydrogen at 800–900° C. results in an increase in strength. The changes occurring during the operation include the liberation of mechanically entrapped gases; the formation and subsequent liberation of gases by chemical action; and the removal of lubricants. Usually, however, lubricants are removed by a preliminary heating to 400–500° C.—a procedure known as "dewaxing."

The time of pre-sintering depends on the size and shape of the compacts, as these factors govern the time in which hydrogen can diffuse throughout the mass to remove oxide. Oxidised cobalt probably tends to give a lower transverse strength due to porosity caused by gas evolution. The cold press method allows more time for reduction of oxides than is available in hot pressing, and it is, therefore, advisable to pre-reduce in hydrogen at 500–700° C. in the latter case.

4.—Sintering

The operation of sintering, by which the product attains its final state, consists essentially of heating through a definite cycle under controlled atmospheric conditions. The pressed pieces may be placed in carbon boats and passed through the furnace under definite time and temperature control, the details depending on the composition of the material being sintered and the mass involved.

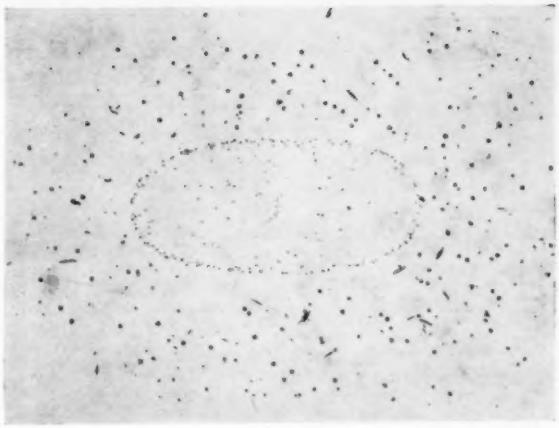


Fig. 3.—Occurrence of eta phase in cemented carbide (6% Co) of low carbon content. Etched in alkaline potassium ferricyanide for 5 seconds. × 10

Sintering will be considered under the following headings: (1) the furnace atmosphere; (2) porosity and shrinkage; and (3) the nature of the bonding action.

The Furnace Atmosphere.—The sintering of cemented carbides is carried out in pure dry hydrogen, or in vacuo, usually the former. Carbon tube furnaces, heated by the passage of a current along the tube, are generally considered the most suitable type, since a slightly carburising atmosphere can be maintained. If decarburisation occurs, it is mainly present in the surface layers of the compact and cobalt usually migrates to the decarburised zone, resulting in the formation of eta phase, which, because of its hard brittle nature is undesirable. Eta phase is a rapidly etching constituent and its presence can generally be detected by immersion of a fractured carbide surface in alkaline potassium ferricyanide solution for a period of 15 seconds, or even less. The eta phase shows up as a brownish area in the fracture which has been thus treated. Fig. 3 shows the appearance of eta phase in a polished and etched surface. Care is necessary to ensure that the hydrogen used is perfectly dry, since water vapour, when associated with hydrogen at high temperatures, can be a very active decarburising agent.

If the atmosphere should be too carburising, excess carbon occurs in the carbide as small rosettes of graphite. They are nowhere near so harmful as eta phase, but they can spoil the appearance of a polished die. Fig. 4 illustrates a polished unetched surface of carbide containing free graphite.

Porosity and Shrinkage.—Porosity can be checked by a density determination, the result being compared with the theoretical density calculated from the densities of the constituents. During sintering, the bonding metal melts and surface tension forces tend to draw the carbide particles closer together. The extent to which this reduction in porosity proceeds is dependent on the particle size and particle size distribution, and on factors which interfere with the surface tension forces or the wetting of the particles. Included in the latter category are impurities of a relatively large size—inclusions; and oxide present as films, or even in solid solution in the carbide.

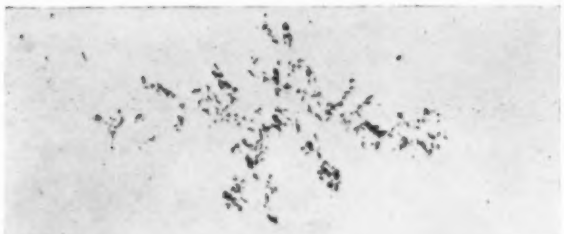


Fig. 4.—Graphite in cemented carbide (WC + 6% Co). Unetched. × 100

Considerable progress in eliminating porosity defects has been made in recent years, through better raw material and process control. The sintering temperature for tungsten-carbide/cobalt compositions varies with the cobalt content, and must be held within fairly narrow limits for individual compositions. Porosity may result from too high or too low a sintering temperature: at low temperatures there is insufficient liquid bond, whilst at high temperatures shrinkage of the cobalt cement occurs as the temperature is lowered.

Nature of the Bonding Action.—At high temperatures solution of tungsten carbide in cobalt takes place. The carbide grains assume a more regular and angular shape, and completely isolated grains grow, indicating a diffusion of the material necessary for growth through the bonding metal. Cemented tungsten-carbide/cobalt alloys show an arrest point at about 1,320° C., suggesting the formation of a liquid phase. Experiments have shown the formation of a solid solution of tungsten carbide in cobalt, and the existence of a eutectic.

Grain growth usually occurs during sintering in the following way. On heating to the sintering temperature, the bonding metal starts to dissolve some of the carbide —usually the smaller and finer particles—and becomes liquid during the process. On cooling, most of the carbide is thrown out and deposited on the existing carbide particles. Owing to the fact that the smaller particles dissolve first, there may result comparatively large barren areas or " lakes " of bonding metal. Where there is no interference to growth, grains of tungsten carbide assume a regular shape. Not quite all the carbide is thrown out of solution on cooling, a very small amount being retained in solution in the cobalt at room temperature.

The hard metals, therefore, are characterised by a structure in which fine carbide particles are held in a matrix of a relatively soft and less refractory metal or alloy. The matrix is usually cobalt and the embedded particles consist of various carbides. Tungsten carbide is the main one always present and, in addition, titanium carbide is included for machining steels. Other carbides used are those of chromium, zirconium, vanadium, niobium and tantalum.

The foregoing description of the mechanism of sintering indicates two important practical points. Firstly, the time of sintering should not be more than that required for complete compaction, thus minimising grain growth; and secondly, the powder used should not include an unduly high proportion of very fine material.

In Fig. 5 can be seen a section of the tungsten-carbide/cobalt equilibrium diagram which gives a guide to what happens during the sintering process.

TABLE II.—SOLID SOLUBILITY AT ROOM TEMPERATURE AND EUTECTIC FORMING PROPERTIES OF THE HARD CARBIDES WITH METALS OF THE IRON GROUP.

Carbide	Nickel		Cobalt		Iron	
	Solid Solubility %	Eutectic %	Solid Solubility %	Eutectic %	Solid Solubility %	Eutectic %
WC ..	25	—	<1	35	5	30
Mo_2C ..	12	30	6	30	2	30
TaC ..	20	35–40	6	35	—	—
TiC ..	almost insoluble		2 phases between 5 and 90% TiC		—	—
Cr_3C_2 ..	8	30	8	35	—	—

The Use of Alternatives to Cobalt for Bonding.

The substitution of nickel for cobalt as a bonding metal for tungsten carbide results in poorer properties of the finished product. The bond is embrittled as a result of the retention of a greater amount of tungsten carbide in solution at room temperature. For the same reason, the quantity of bond is increased, as if 6% nickel were mixed with tungsten carbide there would be 8–9% of bond after sintering.

Iron is also unsuitable, although the ternary eutectic formed melts at 1,085° C., enabling low sintering temperatures to be used. An appreciable amount of tungsten carbide remains in solution at room temperature, resulting in an increased amount of brittle bond. It will be seen that the bond which undergoes the least permanent modification during sintering is most likely to be satisfactory. Table II gives the solid solubility of a number of hard carbides in nickel, cobalt and iron at room temperature, and also the percentage required for the eutectic.

Besides the solubility of carbide in the bonding metal, the cooling rate is also of importance. In the case of the tungsten-carbide/cobalt alloys the phases present at

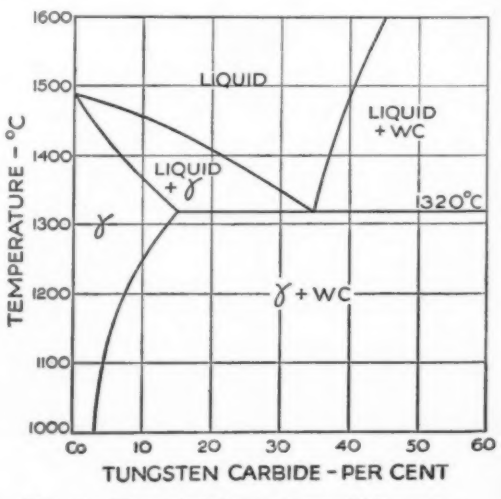


Fig. 5.—The cobalt/tungsten-carbide system.

the sintering temperature are sufficiently unstable not to be preserved if a slow rate of cooling is adopted.

Control of the Physical Properties of the Hard Metals

The conditions for obtaining the best physical properties are very critical and need careful control. For instance, by variation of the amount of bond the toughness can be increased or decreased, with corresponding decrease or increase in hardness: thus a whole range of alloys with graded properties can be produced. The heat treatment depends on the alloy used.

The main factors influencing the physical properties of a sintered alloy depend on: (1) the amount and nature of the bond; (2) the sintering temperature; (3) the particle size and particle size distribution; and (4) the pressure of compaction.

1—Amount of Bonding Metal

Up to 25% of bonding metal is generally used, the actual amount depending mainly on the properties of hardness and toughness required in the final sintered carbide. The transverse strength increases greatly with

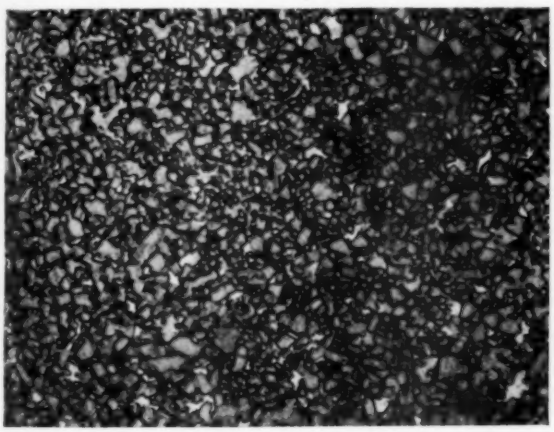


Fig. 6.—Typical structure of cemented carbide (WC + 6% Co). Tungsten carbide grains dark tone and cobalt white. Etched in alkaline potassium ferricyanide. × 1,500

cobalt content, and if high strength is required, extreme hardness has to be sacrificed. Some typical examples are given below:

(1) 4% cobalt alloys are very hard and are used for tool tips taking fine cuts at high speed;

(2) 6% cobalt alloys are used as cutting material for cast iron and non-ferrous metals;

(3) 9% cobalt alloys are used for cutting tools and small wire-drawing dies;

(4) 13% cobalt alloys are used for wire-drawing dies where high strength is essential—also for wood-working tools; and

(5) 20% cobalt alloys are used for heading dies.

Figs. 6 and 7 show the structures of cemented carbides containing 6% and 25%, respectively, of cobalt bond.

2—Sintering Temperature

The sintering temperature varies with composition in rather a narrow range: it depends mainly on the amount

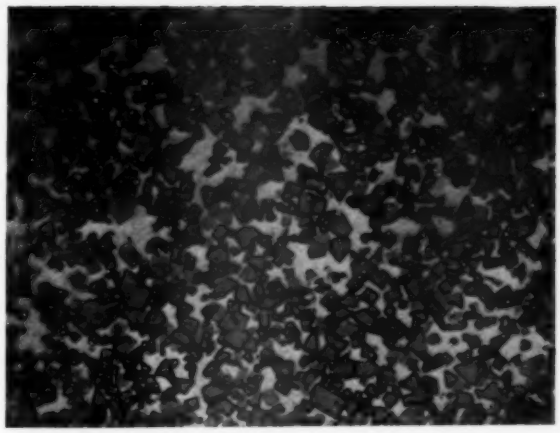


Fig. 7.—Typical structure of cemented carbide (WC + 25% Co). Etched in alkaline potassium ferricyanide. × 1,500

of a given bond. Sintering is usually carried out below the melting point of the pure bonding metal, the solid solution which is formed having a lower melting point. In the case of the tungsten-carbide/cobalt alloys, sintering is carried out at temperatures little higher than 1,420° C.—some 70° C. below the melting point of cobalt. It is important to have sufficient liquid bond to ensure satisfactory sintering: the higher the proportion of bond, the lower the minimum temperature for satisfactory sintering.

Factors which put an upper limit on the sintering temperature are secondary porosity, blistering, and grain growth. Porosity has already been discussed. Blistering occurs mainly in tungsten-carbide/cobalt alloys of high cobalt content. Cobalt absorbs carbon at high temperatures (Fig. 8), with consequent increase in volume causing sweating on the surface. This could be associated with the solution of carbide in cobalt since the volume of liquid would increase considerably at higher temperatures. If sweating is excessive, porosity

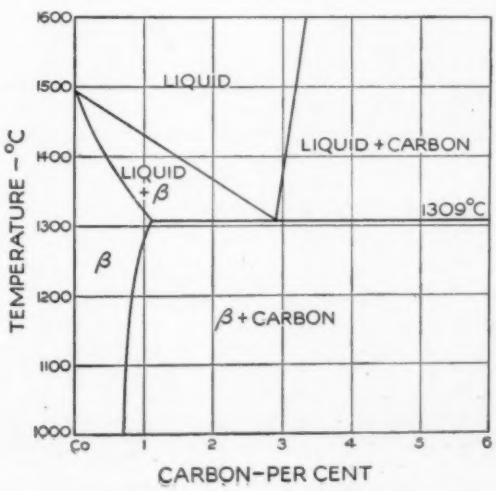


Fig. 8.—The cobalt-carbon system.

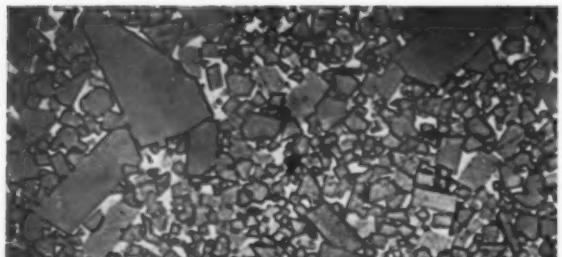


Fig. 9.—Coarse grained cemented carbide resulting from over-sintering. Etched with alkaline potassium ferricyanide. × 1,500

may result on contraction of the molten metal inside the shell of the blister.

The third factor—grain growth—is probably the most significant, since fine grain gives the highest hardness figure for a given cobalt content. At high temperatures the tungsten carbide particles become larger and more regular in outline. The photomicrograph, Fig. 9, shows a typical example of a cemented carbide which has been oversintered. Excessive grain growth has taken place, resulting in a lowered hardness.

By way of comparison, Fig. 10 illustrates a grade of carbide in which the grain size has been deliberately kept very fine in order to achieve maximum hardness for the percentage of cobalt used. Comparing Fig. 10 with Fig. 6 which is of the same composition, the respective hardnesses would be in the region of 1,750 and 1,550 V.P.N.

Sintering should only be continued for sufficient length of time to ensure complete compaction.

3–Particle Size and Distribution.

The size of the original carbide particles is of some importance, since grain growth causes decrease in hardness. The maximum particle size of cemented carbide is about 20 microns, and the maximum number of particles occurs at about 2 microns. If, however, all the particles are the same size (and shape), then this results in maximum porosity. Porosity can be minimised by a suitable size distribution, such as a high percentage of particles of one size with sufficient fine material to fill the interstices. An excessive proportion of fine material is usually to be avoided since this easily dissolves and causes grain growth.

4–Pressure of Compaction

With increasing pressure of compaction, the hardness of cemented tungsten-carbide/cobalt compacts tends to a maximum and then diminishes: the finer the powder, the less marked the maximum in hardness. The fall in hardness with pressure after a certain point is probably due to entrapped gases which are unable to escape through the denser compact during pre-sintering or sintering. Again, if the pressure is too high, the sintered material shows press cracks which severely reduce its strength.

Process Control Methods

Hardness, density, transverse strength and microscopic examination are used for both process control and experimental investigation. In addition, cutting tests on tools and life tests on dies, etc., are extensively used when developing new types of carbide.

Hardness Determination.—The usual method of hardness testing is by means of the Vickers pyramid diamond indenter. All surfaces on which readings are to be taken are lapped parallel to the bottom surface. It is difficult to obtain satisfactory readings when cemented carbide parts are brazed or held in steel supports.

Hardness figures cannot be used to indicate cutting tool efficiences, especially when two types of carbide are being compared, but when proper control is exercised during manufacture the variations of hardness for a given grade of carbide are small, and the hardness test is thus valuable for control purposes.

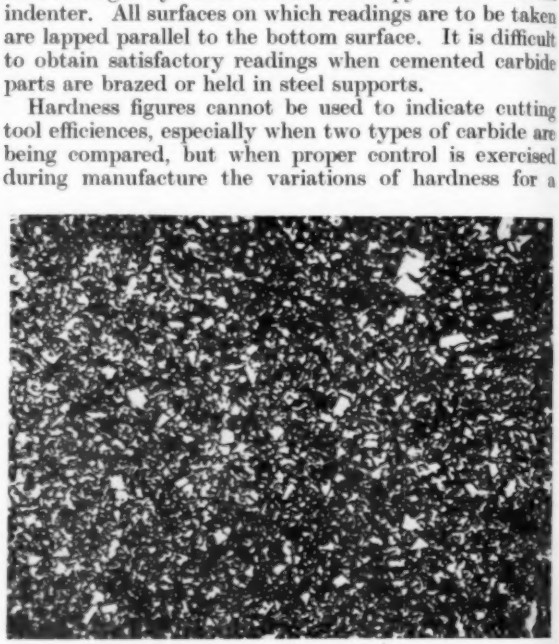


Fig. 10.—Typical structure of cemented carbide (WC + 6% Co) in which the tungsten carbide grains have been made very fine in order to produce very high hardness. This grade is used for machining chilled irons and high speed machining of normal irons, hard brass and other abrasive metals. Etched with alkaline potassium ferricyanide. × 1,500

Density Determination.—This test is carried out by the usual water displacement method, the weight of the carbide in air and water yielding the density by simple calculation. The density determination acts as a check on porosity and constitution. With most cemented carbides, the density will decrease as the amount of bond increases.

Transverse Strength.—The cemented carbides possess little or no ductility, and the strength is measured by calculating the modulus of rupture or maximum stress by means of test bars broken transversely. Rectangular or square-sectioned bars are used as test pieces and, as the material is very notch sensitive, they must be finely ground with parallel sides. Even when these precautions are taken, appreciable scatter of the results can occur. Transverse strengths of cemented carbide grades vary from some 200,000 lb./sq. in. for 6% cobalt bond to 350,000 lb./sq. in. for 20% bond.

Microscopic Examination.—Samples of cemented carbides may be examined and photographed at magnifications up to 1,500 for the purpose of control. The

specimens are prepared by first grinding with silicon carbide wheels, followed by diamond-loaded cast-iron laps, and finally polishing with fine diamond dust. The usual etching solution consists of equal parts of 10% solutions of potassium hydroxide and potassium ferricyanide: the etching time is usually in the region of 3 minutes.

Carbide Compositions for Steel Cutting Tools

Straight tungsten-carbide/cobalt alloys are very successful for cutting most non-ferrous alloys and cast iron, but when used for steel a defect known as cratering occurs. The type of chip produced seems to be the important factor, and it may be said that these straight alloys are satisfactory for machining materials which give "crumby" chips, with which the heat generated by the tool is concentrated at the cutting edge.

Steels usually give long spiral turnings and the main contact of the chip with the cutting tool is not at the cutting edge but some distance behind it. The rapidly moving hot turning rubs the surface, resulting in tearing out of carbide grains, which eventually causes the formation of a crater. Enlargement of the crater then takes place until, finally, the tip breaks off. This effect can be eliminated by using tungsten carbide compositions containing tantalum carbide or titanium carbide bonded with cobalt. The particular feature of these alloys is their low thermal conductivity, compared with the straight tungsten-carbide/cobalt compositions. It is difficult to understand why this should account for

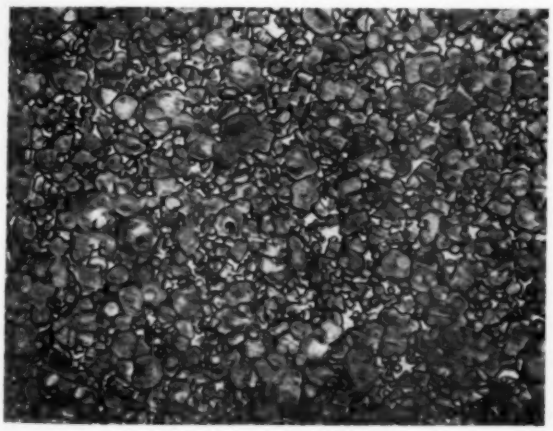


Fig. 11.—Typical structure of steel-cutting grade of cemented carbide (WC+15%TiC+8%Co). The rounded grains are titanium-carbide/tungsten-carbide solid solution. Etched with alkaline potassium ferricyanide. × 1,500

the improvement, as the heat is not conducted away so rapidly. It may be that the fact that both chip and surface are hotter results in lower frictional forces.

An addition of 12% titanium carbide results in a hardness comparable with that of pure tungsten-carbide/cobalt alloys, but the titanium carbide lowers the strength of the cemented carbide considerably. The photomicrograph (Fig. 11) shows a typical structure of a grade of cemented carbide containing titanium carbide. In addition to the angular grains of tungsten carbide, there are rounded grains due to the titanium-carbide/tungsten-carbide solid solution.

Constitution of Complex Carbide Alloys

The refractory carbides readily form "alloys" with each other where the degree of solid solubility varies with the carbides. The presence of two hard carbides in a cemented alloy will affect the hardness in the following manner. If the carbides are mutually insoluble in the solid state, then the system will consist of a mixture of the two unchanged components and the hardness will be a linear function of composition. If, on the other hand, a continuous series of solid solutions is formed, the hardness curve has a maximum corresponding with equal atomic percentages. The solution of one metal in another increases the hardness of the solvent metal, and a similar effect is to be expected with solid solutions of carbides.

Solid solutions of two metals have lower thermal conductivities than either of the constituents and the same is probably true of carbides, since the addition of titanium carbide to tungsten carbide results in a decrease in thermal conductivity.

From the foregoing considerations, it seems best, therefore, to have complex carbides entirely in the form of solid solutions, although the presence of bonding metal is a factor to be taken into account.

Comparison of Cemented Carbides with High Speed Steels

Fig. 12 shows the structure of a typical high speed steel, containing 18% tungsten, 4% chromium and 1% vanadium, in the hardened and tempered condition. Although such a structure is, in reality, rather complex, its metallography is relatively straightforward, and some comparison with that of cemented carbides can be made. High speed steel contains stable double carbides which may be likened to the single and double carbides present in cemented carbide. The "bond," or matrix, in high-speed steel contains iron tungstide and other constituents in solid solution, and in the hardened and tempered condition it is usually martensitic. Thus, the "bond" in high speed steel is much harder than, and is present in much greater proportion than, the bond in cemented carbide. It has, therefore, a much greater influence on the material as a cutting tool, and is much more affected as cutting and wear conditions become more severe.

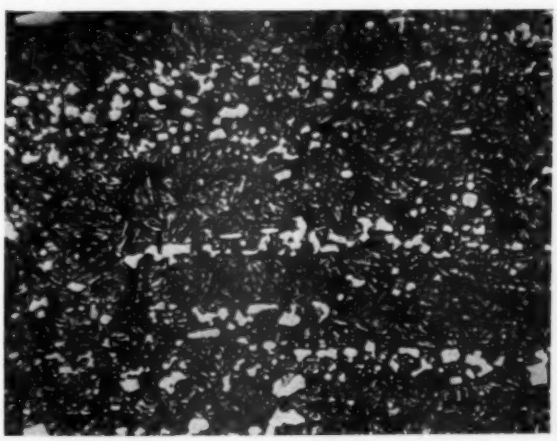


Fig. 12.—Typical structure of hardened and tempered high speed steel showing carbides (white) in a martensitic matrix. Etched in 2% nital. × 400

The Vickers diamond hardness of the high speed steel illustrated in Fig. 12 is 850, whilst that of a typical steel cutting grade of cemented carbide is about 1,500.

The author wishes to thank Mr. A. E. Oliver, chief chemist and metallurgist of Hard Metal Tools, Ltd., for supplying the photomicrographs of cemented carbide, and Dr. E. J. Sandford, senior metallurgist, for helpful criticism.

Steel Castings Research in the United Kingdom

British Steel Castings Research Association Formed

THE formation, which has recently been announced, of the British Steel Castings Research Association is an event of importance and significance not only to the British steelfounding industry itself, but also to the engineering industry, with which the former is clearly so closely allied. It can indeed be said to mark a further major step in the development of steel castings research resources in the United Kingdom. The B.S.C.R.A. inherits from its predecessor, the Research & Development Division of the British Steel Founders' Association, an active and established research organisation, with a comprehensive programme of research and development work already well in hand.

The first Chairman of Council is MR. F. N. LLOYD, and MR. J. F. B. JACKSON, B.Sc., A.R.I.C., F.I.M., who, as Director of Research to the British Steel Founders' Association, has had the responsibility for organising and building up its Research & Development Division since its formation in 1949, has been appointed as Director of the British Steel Castings Research Association. MR. R. BARBER, A.C.I.S. has been appointed Secretary.

The B.S.C.R.A. research programme, as it now becomes, is not only sponsored in various Universities, but is also conducted by its permanent staff, both independently in its own research stations and in conjunction with the many well-equipped research laboratories and plants of industrial concerns. Its researches over the last three years have ranged over a wide field of steel casting science and foundry technology, and have included an important series of projects related to industrial health and to foundry dust suppression. The B.S.C.R.A. Dust Research Station in Sheffield has been in operation since mid-1951, and to the manufacturers of steel castings in this country goes the credit of being the first section of the founding industry to set up an experimental unit of this kind devoted solely to such work.

Important advances have been made in relation to the non-destructive testings of steel castings, and these are to be the subject of a B.S.C.R.A. One-Day Conference of the representatives of member firms, to be held in Glasgow during April. Research, conducted at the University of Durham and at the Imperial College of Science, is leading to the establishment of essential basic data relating to the mechanism of freezing of steel in refractory moulds, and to findings that will undoubtedly have their influence upon industrial practice. Research in Cambridge on the metal penetration problem and towards the improvement of surface finish in steel castings has continued since 1950. B.S.C.R.A. research relating to the influence of moulding materials upon hot tearing in steel castings is to be the subject of a paper to be presented at the 57th Annual Convention of the American Foundrymen's Society in Chicago later this year.

Although some indication of the scope of the research activities that the steelfounding industry is conducting on a collective basis is afforded by the preceding comments, for a more complete appreciation of this reference should obviously be made to one or more of the published statements, devoted solely to this topic, that have from time to time appeared in the technical press over the last three years. From these it will be noted that since the formation of the B.S.F.A. Research & Development Division in 1949, the steelfounding industry's research has been so organised that its results are disseminated and discussed, not only at management and technical levels, but among those in whose hands the application of research findings ultimately rests, i.e. those who are actively engaged upon the foundry floor.

The problem of translating the results of research and development into practice has thus been fully recognised by those in the steel-founding industry responsible for initiating co-operative research, and it is the intention of the B.S.C.R.A. to intensify these efforts by all the means at its disposal, and, particularly by discussion and by direct demonstration, to bring science into practice.

It will be the policy of the B.S.C.R.A., not only to maintain but to extend the cordial relations and contacts already established between the B.S.F.A. Research & Development Division and kindred research organisations in Great Britain and the Commonwealth, and in Europe and America.

Aluminium Welding Demonstrations

"THE Welding of Aluminium Alloys by the Latest Production Techniques" is the subject of a series of demonstrations being arranged by Northern Aluminium Company Limited at various centres throughout the country. At each, the welding of aluminium by the shielded inert-gas metal-arc and the argon tungsten-arc processes will be demonstrated, followed by the first showing in this country of two films, "Aircomatic Welding" and "The Study of Arcs in Sigma Welding." The programme will conclude with a discussion.

The first demonstration was held on the afternoon of Wednesday, March 18th, at Slough, and others on Wednesday, March 25th at Enfield, and on Wednesday, April 1st, at the Southampton Technical College. Arrangements are being made to hold subsequent demonstrations at Bristol, Cardiff, Birmingham, Liverpool, Manchester, Leeds, Sheffield, Newcastle and Glasgow within the next few months.

As the number attending each demonstration is necessarily limited, invitations are being sent to individuals known to be particularly interested. Others who wish to attend any of the demonstrations are, however, invited to contact Northern Aluminium Company's Sales Development Division, Banbury, Oxon.

Metallising of Glass, Ceramic and Plastic Surfaces

By R. J. Heritage and J. R. Balmer

Telecommunications Research Establishment, Great Malvern.

In recent years, there has been a growth in interest in the coating of glass, ceramics and plastics with films of metal. Besides decorative possibilities, there are a number of industrially important applications in the electrical and optical fields. Three important techniques are discussed, namely, reduction from aqueous solutions; reduction by heat; and evaporation in a vacuum.

THE term "metallising" implies the coating of a surface, wholly or in part, with a metal layer, to confer on it desirable chemical and physical properties. In recent years, interest in the many uses of the metallising processes has increased and, in addition to decorative possibilities, various industrial and scientific applications have been found. These include the coating of mica and plastic materials with silver for condensers, silver or aluminium deposits on glass surfaces for optical and thermal reflectors, as well as the use of metal films for resistors, conductors and rectifiers. In addition to the older well-known methods, alternative and more efficient processes have been found, and the art has now become a reliable and effective tool for commercial applications.

In this account, three metallising techniques are described, namely, reduction from aqueous solutions, reduction by heat, and the evaporation of metals in a vacuum; this is followed by a comparison of the methods and a survey of their uses. Throughout the text, references to other works are quoted to enable the reader to explore the subject more fully than present space permits.

Reduction from Aqueous Solutions

The success of this method depends to a great extent on the freedom of the surface from grease. Many degreasing solvents are available but the choice must depend on the particular material under process. Glass and ceramic materials may be very efficiently degreased with caustic alkalis followed by nitric acid, but for plastics, organic reagents or mild alkalis which do not attack them must be used.

After this preliminary degreasing, the surface is often activated by immersion for some few minutes in a suitable solution. The agent commonly used for this activation is an acid solution of stannous chloride, of which the most suitable concentration is about 10%. Other agents used for the same purpose include a 2% aqueous solution of pyrogallol or hydroquinone, or ammoniacal ferrous sulphate solution.

Silvering Processes

In general, these methods involve the reduction of a silver complex by a suitable reagent in solution. The preference for a particular method is a matter of personal choice; the examples listed below are equally applicable to glass, ceramic or plastic materials.

(*a*) *Cane Sugar Reduction.*—The silvering solution is made up as follows:

2 g. of silver nitrate are dissolved in 200 ml. of distilled water, and to this a 20% ammonia solution is slowly added, with stirring, until the brown precipitate redissolves; 10 ml. of 10% potassium-hydroxide solution are then added, followed by ammonia until the solution remains faintly turbid, after which the whole is filtered.

The reducing solution, which is composed of:

Cane sugar	100 g.
Nitric acid	5 ml.
Ethyl alcohol	200 ml.
Water	1,000 ml.

should be kept in a dark bottle for two weeks before using.

In use, 10 ml. of reducing solution is added to each 20 ml. of ammoniacal silver solution. It is convenient to cool the solutions before mixing, as this prevents too rapid a reduction, which would result in much silver being wasted in the form of powder.

(*b*) *Formaldehyde—Rochelle Salt Reduction.*—This method, which is a combination of two well-known methods, has been used by the authors for deposits of greatest adhesion. Following an activation in stannous chloride solution, the material is immersed for a few minutes in a mixture of 3 volumes of methyl alcohol and 7 volumes of formalin (40% formaldehyde solution). For silvering on glass surfaces, a small addition of 10% stannous chloride solution to the mixture is found to be an advantage. After thoroughly washing the surface in distilled water, the material is immersed in the silvering solution, made up as follows:

(i) 30 g. silver nitrate are dissolved in 300 ml. distilled water and ammonium hydroxide is added until the brown precipitate first formed redissolves (the solution should smell slightly of ammonia); the volume is then made up to 600 ml. with distilled water.

(ii) 30 g. Rochelle salt (sodium potassium tartrate) are dissolved in 400 ml. distilled water.

Solutions (i) and (ii) are filtered, and mixed immediately before use. Normal silvering should take from 20 to 30 minutes, but as much as one hour may be allowed for a thicker deposit. In general the longer the immersion period the less adherent is the deposit.

(*c*) *Hydrazine Sulphate Reduction.*—This method is suitable for ceramic, glass and plastic bases. The material is degreased and activated in 10% stannous chloride solution. After washing in water, it is immersed in a 2% solution of silver nitrate in distilled water until

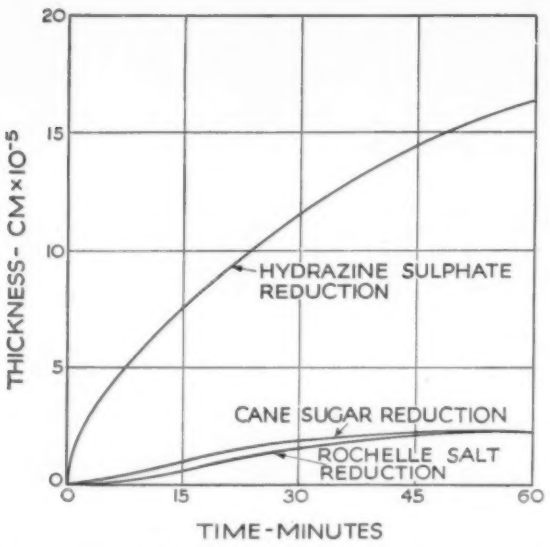


Fig. 1.—Rate of deposition of silver on glass by various methods.

a faint brown colour is acquired. The surface is then washed with water and covered with the following mixture until the required thickness of silver is obtained.

(i) 70 ml. ammoniacal 1% silver nitrate solution.

(ii) 10 ml. pyridine, 16 ml. of 1·25% hydrazine sulphate solution.

Solutions (i) and (ii) are mixed immediately before using. The pyridine retards the reduction of silver and more or less than the specified amount may be used.

An interesting modification[1] of this process is the application of silver solution and reducing agent to the surface to be coated by means of fine sprays directed from separate nozzles, thereby economising in the use of silver.

In comparing the three silvering processes outlined, it may be stated that as far as the adhesion and fineness of the deposit is concerned the Rochelle salt reduction gives the best results, but the efficiency of the solution is far less than the other two methods. The Rochelle salt process is ideal for coating plastic, ceramic or glass surfaces prior to electro-deposition, when adhesion and not thickness of the film is the criterion; it is also suitable for producing very thin films for use as half-silvered mirrors in optical instruments.

The rate of deposition of silver by the three methods is compared in Fig. 1. Although deposition may be continued for longer periods than those shown, the films tend to become loose after too long a period, and after one hour most of the silver is precipitated as a powder.

Metals other than Silver

Copper Mirrors.—After activation with stannous chloride solution, ceramic, glass or plastic surfaces may be coated with copper by immersion in the following mixture:

Copper sulphate	5 g.
Water	200 ml.
Ammonium hydroxide	20 ml.

and

Rongalite (sodium formaldehyde sulphoxylate)	5 g.
Water	100 ml.

A second method recommended by M. Volmer[2] use the following solution:

Copper sulphate	4 g.
Sodium hydroxide	7 g.
Rochelle salt	18 g.
Potassium sulphate	10 g.
Water	1 litre
Formalin solution	15 ml.

The surface to be coated should bear a very thin film of gold before immersion in the metallising solution, and this is readily effected by a dip in 1% gold chloride solution immediately after activation with stannous chloride solution.

Gold Mirrors.—A very satisfactory method for depositing gold mirrors uses the following solutions after activation as above:

(i)	Gold chloride	1 g.
	Water	250 ml.
(ii)	Potassium carbonate	8 g.
	Sucrose	1 g.
	Formalin	1 ml.
	Water	250 ml.

Equal parts of (i) and (ii) are mixed before use. This method can be used for glass and plastic surfaces, but it has been found that prolonged immersion causes stripping of the gold deposits.

Antimony Mirrors.—A method for producing bright antimony mirrors[3] relies on the reduction of antimony trichloride by tartaric acid and formaldehyde. For success in this method the surface to be mirrored should bear a very thin film of gold.

Alloy Mirrors.—Methods for producing alloy mirrors have been devised, and in particular silver alloys may be readily obtained by reduction of mixed solutions of silver and other metal salts. Silver-copper alloy mirrors are produced by reducing mixed solutions of the metal salts with Rochelle salt and tartaric acid, or with formaldehyde[4, 5]. A patent by A. Rost[6] gives a method for obtaining a platinum-silver mirror while another patent by Ermes[7] details a solution which gives an alloy mirror of silver, copper, nickel, zinc and chromium. The mirror is reputed to be extremely hard and resistant to corrosion. A large number of references to metallising methods is included in a paper by B. P. Upton[8] which deals with reduction from aqueous solutions.

Firing Methods

These methods usually depend on the reduction of metal compounds by heat. This fact limits the use of the methods to base materials which are capable of withstanding high temperatures, and to metals whose compounds are reducible by heating. It is well known that salts of the so-called noble metals decompose at elevated temperatures, and of these, platinum, gold, palladium and silver are commonly used in metallising solutions for firing on glass and ceramic bases.

The solutions indicated below are readily made up in the laboratory and they have been found to yield satisfactory films on both glass and ceramics.

Silver

Metallic paints for silver usually comprise finely divided silver and a flux in a suitable oil medium. The flux often used is lead borate, and a typical formulation is:

Silver powder	2 g.
Lead borate	1 g.

These are mixed to a paint-like consistency with lavender

oil, or rosemary oil, and after application the suspension is dried and fired.

Greater adhesion is obtained by incorporating a fluoride in the flux and an example of this type of mixture is :

Silver powder	60 g.
Lead borate	3 g.
Bismuth nitrate	1·5 g.
Lead fluoride	5·5 g.
Lavender oil	30 g.

The paint is suitably applied to a glass or ceramic base and fired at about 650° C.

Gold

Gold films may be obtained from solutions of a similar composition to those for silver, but the gold powder used should be very finely divided. A suitable flux consists of :

Bismuth nitrate	12 g.
Sodium borate	1 g.

This is mixed with the gold in the proportions :

Gold	10 g.
Flux	1 g.

Another simple metallising solution for gold is made by mixing gold chloride with a small amount of rosemary oil and diluting the resulting paste with lavender oil ; the solution is then fired at about 600° C. in an oxidising atmosphere. A further method for producing gold films which requires only moderate heating has been described by Gibson[9].

Platinum

Glass or ceramic surfaces may be platinised by the reduction of platinum chloride solution by heat. The solution is made by mixing dry platinic chloride with rosemary oil until the consistency is that of a thick paste. If the solution is to be used to provide a base for soldering, it may be used as such, but if it is for mirroring it should be diluted with rosemary or lavender oil. The solution is applied, allowed to dry and then heated to about 650° C. ; for glass surfaces, the temperature should be raised to the softening range to obtain greatest adhesion. This process may be applied to ceramic, mica, and quartz as well as platinum and nickel surfaces ; the thicker mirrors can be used as a base for soft soldering.

As in the case of silver and gold, greater adhesion may be obtained by the addition to the platinising solution of a suitable flux ; boric acid, lead borate, and bismuth chloride are commonly used fluxes.

A typical example of a solution with flux additions is :

Platinum chloride	5 g.
Lead oxide	0·1 g.
Lead borate	0·1 g.
Lavender oil	10 g.

It is applied to glass or china and heated to 650° C.

Other Metals

Chlorides of palladium, rhodium, ruthenium and iridium may be substituted in the examples above for platinum chloride, while examples of other solutions are to be found in the patent literature[10, 11]. A process for coating osmium on both metallic and non-metallic bodies has been described[12], while a further method[13] covers other platinum metals.

Evaporation

Essentially, evaporation as applied to metallising processes, consists of heating a metal in a high vacuum until its vapour pressure exceeds 10^{-2} mm. of mercury. In practice, a small amount of the metal is heated (usually electrically) on a tungsten wire or spiral and, as it vaporises, molecular rays are emitted in all directions ; the vacuum required is of the order of 10^{-5} mm. of mercury.

Some values for the evaporation temperature, defined as the temperature at which the vapour pressure of the metal reaches 10^{-2} mm. of mercury, are given in the table below.

TABLE I.—EVAPORATION TEMPERATURES OF VARIOUS ELEMENTS

Metal	Temperature ° C.	Metal	Temperature ° C.
Cadmium	268	Silver	1,045
Zinc	351	Gold	1,173
Magnesium	440	Aluminium	1,188
Calcium	606	Copper	1,270
Barium	632	Iron	1,420
Bismuth	640	Nickel	1,444
Antimony	700	Platinum	2,059
Lead	728	Molybdenum	2,481
Tin	876	Carbon	2,522
Chromium	917	Tungsten	3,232

The choice of heater material and its form depends upon the metal to be evaporated : for instance, aluminium may be evaporated from a loop of tungsten wire since on melting the metal wets the tungsten and adheres to it, but silver and gold are best evaporated from a small tungsten boat or a conical basket. Detailed comparisons of various heater forms are described in an article by Olsen, Smith and Crittenden[14]. Other useful data on evaporation are given by J. Strong[15], and Dushman[16].

Electrodeposition on Metallised Coatings

It is often desirable to thicken the films produced by metallising, and for this purpose numerous electroplating solutions have been developed. To prevent chemical attack on the initially thin films, the usual practice is to begin deposition from a special bath and then to transfer to the normal plating bath for building up. It is advisable however, to electroplate as soon as possible after metallising, otherwise the surface may become contaminated with films of oxide or sulphide and poor adhesion will result.

For thickening silver films the following bath has been found most satisfactory :

Silver nitrate	25 g.
Sodium cyanide	28 g.
Potassium nitrate	100 g.
Water	1 litre

The current density should be 0·5 amp./sq. dm. and the bath should be agitated. Silver anodes are used and the temperature should not fall below 25° C. After deposition of 0·0005 in. of silver the more usual bath may be used, for example :

Silver cyanide	45 g.
Potassium cyanide	60 g.
Potassium carbonate	50 g.
Water	1 litre

This bath is used at a current density of 0·3 amp./sq. dm. and a temperature of 25° C. For the deposition of copper on metallised coatings, the ordinary acid sulphate bath may be used, but there is less tendency to rupture the deposit in the initial stages if the alkaline copper sulphate solution is used.

Copper sulphate	50 g.
Sodium hydroxide	45 g.
Rochelle salt	150 g.
Water	1 litre

The current density should be about 0·5 amp./sq. dm., and the temperature is best maintained at 25° C.

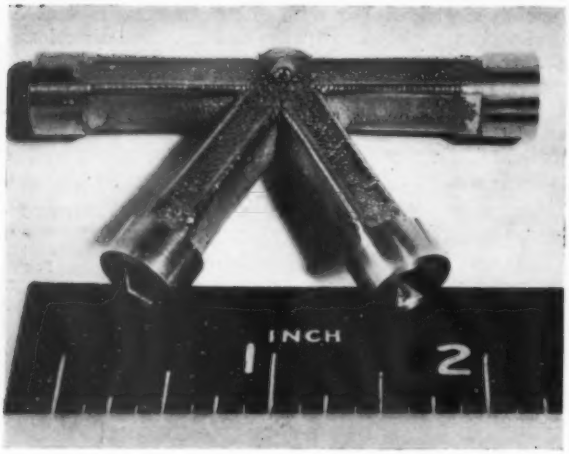


Fig. 2.—Electroformed waveguide.

A bath which has been found most suitable for the initial deposition on chemically reduced films is the triethanolamine bath described by Schweitzer[17]. A typical example is:

Copper sulphate	25 g.
Rochelle salt	10 g.
Triethanolamine	25 ml.
Water	1 litre

The current density recommended is 0·3 amp./sq. dm., and after plating for 15 minutes the article should be transferred to the normal acid copper bath.

A nickel bath recommended by Crocker[18] is composed of:

Nickel sulphate	100 g.
Boric acid	10 g.
Water	1 litre

It is also suitable for an initial deposit of nickel on the metallised films. A further solution used for nickel employs ammonium chloride in place of boric acid.

In electroplating on metallised coatings, care must be taken to ensure that the voltage is applied before immersion of the object in the bath, thus minimising attack on the films by the plating solution. Another precaution worthy of note is that heated solutions should be avoided, since the large differences in expansion between metals and plastic or glass bases will cause stripping or lack of adhesion. It may also be mentioned that solutions which are strongly acidic or strongly alkaline should not be used, or attack on the base materials may occur. When adequate measures are taken, however, the baths detailed above will be found to give excellent deposits.

Comparison and Uses of the Methods

One advantage of metallising by reduction from aqueous solutions is that no elaborate equipment is required for the process, and since in the majority of applications silver is used, the limitation of the possible metals reducible from solutions is not serious. The method is particularly suitable for providing conducting metal films on insulating materials prior to electrodeposition, and a typical use of this is in electroforming practice. By this means, complex shapes in plastics or waxes are reproduced in metal by building up thick electrodeposits on the initial metallised films until they possess the necessary mechanical strength. This enables many intricate shapes to be made in a much simpler and less expensive manner than could otherwise be possible by machining. An example of an electroformed waveguide component is shown in Fig. 2 to illustrate this technique.

The firing method is limited in use to vitreous materials capable of withstanding high temperatures, but the value of the process is in the great adhesion of the metal coat when correct conditions are applied. This process has long been used in pottery decoration, but one of the more recent developments is the use of the metal film as a resistance material. Resistors produced by engraving thin metal films of a gold-platinum mixture fired on glass or glazed ceramic surfaces have been found to be extremely stable and reliable, possessing all the properties of a high grade component. Various types of resistor have been made[19], and these include a flat-plate form, with a zig-zag film pattern, enabling a high resistance to be obtained in a small space, spiralled films on glass rods, and metallised glass fibres of 0·001 in. diameter. Other types attempted include flat-plate circuits and experimental potentiometers.

The wide range of metals as well as salts which can be deposited by evaporation makes the process invaluable in many ways, but it suffers from the disadvantage that only flat or slightly curved surfaces can be coated, and the equipment required is specialised. The best optical mirrors are produced by evaporating aluminium or silver on highly polished surfaces, such reflectors needing no subsequent treatment. In one method of constructing rectifier units, selenium is evaporated on steel discs, and the process is also used for depositing photo-cell elements.

It is evident that each of the processes has its own merits and none is suitable for all applications, but together they constitute a valuable asset with a wide field of usefulness.

Acknowledgments

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REFERENCES

1 British Patent 524,753; 537,987; 538,928.
2 German Patent 390,145.
3 U.S. Patent 2,278,722.
4 U.S. Patent 1,935,520.
5 *J. Electrochem. Soc. Japan*, 1934, **2**, 375.
6 German Patent 77,725.
7 German Patent 587,353.
8 *J. Electrodepositors Tech. Soc.*, 1947, **22**, 45–72.
9 *Nature*, 1937, August 14th, 279.
10 U.S. Patent 2,166,076.
11 U.S. Patent 2,328,101.
12 British Patent 304,580.
13 British Patent 304,396.
14 *J. Applied Phys.*, 1941, November, **12**, 779.
15 J. Strong. "Procedures in Experimental Physics", 1945, Prentice-Hall, Inc., N.Y. p. 151.
16. S. Dushman. "The Scientific Foundations of Vacuum Technique", 1949, Chapman & Hall, London.
17 British Patent 503,095.
18 British Patent 397,397.
19 *Electronic Engineering*, 1952, July, 324.

Pallet Storage Film

A 25-minute film made by the Materials Handling Division of Fisher & Ludlow, Ltd., Bordesley Works, Birmingham, 12, shows the methods used to store large quantities of box pallets at the Company's Castle Bromwich Works. The Flowblock pallet storage system conserves floor space and makes possible the rapid location of the required components stored in any one of the thousands of pallets in the system, which contains some 75,000 different components.

The Foundations of Metallography

Institute of Metals Presidential Address

In surveying, in his Presidential Address to the Institute of Metals, the state of metallographic knowledge at the time the Institute came into existence almost fifty years ago, Professor F. C. Thompson paid tribute to the early workers in this field for the firm foundations they had laid, and pointed out that the existence of several phenomena which have only recently been studied extensively was at least surmised, and in some cases known.

THE Institute of Metals came into existence at a time when the foundations of scientific metallography had been well and truly laid. The advances which have been made since then have in no inconsiderable degree been the result of the work of our own Members, and much of this work is recorded in our *Journal*. The Institute may take a legitimate pride in the part which it has played in fostering knowledge in its own field of science. It seems worth while, therefore, to look back and spend a few minutes in considering the state that metallography had reached when the Institute came into existence in 1908.

The metallographic techniques then available were the microscopic examination of metals and alloys; the construction and interpretation of thermal-equilibrium diagrams and their correlation with a wide range of chemical, physical, and mechanical properties. These techniques are still employed, though now enriched by others which have since been developed.

Although modern microscopic techniques, such as phase-contrast or the use of polarized light, had not then been applied to metallic systems, the results obtained by the older metallographer were of a high standard, being little, if at all, inferior to those obtained to-day. In no instance is the swing of the pendulum of scientific fashion more evident than in the return to favour of the microscope, with its new accessories, after a period of semi-eclipse, during which some people believed that other, and more modern, techniques had rendered it obsolescent and perhaps even obsolete. After Sorby's disappointment at the earlier neglect of his work, it can readily be imagined with what pleasure he would have welcomed these further developments of the microscope for the examination of metals.

In 1908 most of the methods now employed for the development of microstructures had already been introduced. Heat-tinting had been used with success by Martens, and methods for etching both at high temperature and in vacuum had been employed. A technique then common, but which has since tended to fade out, was the simultaneous polishing and etching, known as "polish-attack," but, in some forms of electrolytic preparation, something not very different from this has again come to the front.

Not only was it *known* from evidence drawn from a wide variety of sources that the grains in a metal or alloy were crystalline, but the occurrence of sub-crystalline structures had been observed by Andrews as early as 1895. Howe, too, had recognized grains of the "first and second orders"; what in the case of iron, we should now call α-veining, the smaller grains being regarded by him as "irregular fragments into which the larger grains had been broken." That this sub-granular structure consists of fragments of almost identical orientation was supported by the already well-known fact that slip bands passed from one cell to another without appreciable deviation, unlike the marked change of direction which normally occurs at the crystal boundaries.

Equilibrium Diagrams

Work on the thermal-equilibrium diagrams of metals will always be connected with the names of Roozeboom and especially of Heycock and Neville, and it is of interest that in his recent book on thermo-dynamics of alloys Lumsden[1] deliberately employed some of their data as being, for this purpose, the best even yet available. Nor was the early work by any means confined to alloy systems of low melting point, for Carpenter and Keelings' iron-carbon diagram was published in 1905. Although such diagrams were essentially regarded as being expressions of experimental fact, the surfaces depicting the heat contents of alloys had already received consideration, a point of view which a little later was discussed by Tammann, and which clearly bears some relationship to the more modern concept of "free energy."

The preparation of pure metals by electro-deposition was an already established technique, and work on the properties of iron, using electrolytic material, which even to-day would be regarded as of high purity, had been done by many people. It was also appreciated that the properties of such iron as deposited differed greatly from those of the same metal in the normal condition, and further that this difference might be due on the one hand to some unknown change of structure, or on the other to the occlusion of hydrogen, the effect of which gas on iron, and particularly on palladium, had been extensively studied.

The sub-division of metallic alloys into eutectics, solid solutions, and intermetallic compounds had long been understood, and the work of Matthiessen had correlated such metallographic structures with physical properties such as electrical conductivity. Although the arbitrary separation of metallography into the ferrous and non-ferrous fields is of long standing, it is, in fact, one indivisible branch of knowledge. This is well exemplified by Arnold's paper of 1895 on "The Influence of Carbon on Iron"[2]. Shocked to the core as he himself would have been to be told so, this paper is of importance in that it represents one of the earliest attempts to examine in detail the breakdown of a solid solution into a eutectoid.

At the time which we are considering, the idea of the superlattice had not, so far as I am aware, been enunciated, but the evidence again was there. When Roberts-Austen published his liquidus curves for the copper-zinc system in 1897, a horizontal line at a temperature of about 470° C. was introduced over the

range in which the β-phase exists. I believe that Le Chatelier had also observed an abnormality in the cooling curve at this point, and I may perhaps be permitted to digress somewhat to remind you of the fact that it was Tammann who, in 1918, first suggested in the words of Desch: "That a kind of isomerism was possible in alloys consisting of a solid solution; that is, there might be two alloys of the same composition, each consisting of a single phase and having the same crystalline form but differing in properties. These differences would arise from the different distribution of the several kinds of atoms on the points of the space lattice." This work of Tammann is not as generally known as it deserves to be, and it is a pleasure to pay tribute to a master of our science.

Importance of Atomic Volume

The first attempt to elucidate the relationship between atomic volume and the mechanical properties of alloys seems to have been due to Roberts-Austen. His work, coupled with that of Arnold and Jefferson on gold, and of Arnold himself on iron, had demonstrated that, so long as the added element passed into solid solution, the relationship of the atomic volumes of the solvent and solute atoms was a potent factor in controlling the strength (or in other words the structure) of the alloy. Looking back on this work in the light of present knowledge, it is clear, although the fact was then but dimly perceived, that the whole evidence required for an appreciation of the influence of the "size-factor" was already there. The Second Report to the Alloys Research Committee[3] in 1893 concludes that: "In all probability, therefore, the introduction of free molecules of an added element must create a disturbance, the nature and magnitude of which will bear some relation to the volume of the disturbing atom." The other factors determining solid solubility were still unknown until they were later revealed by the work of Hume-Rothery. It is of interest, too, that the possibility of interstitial as well as of substitutional solid solutions was thoroughly well appreciated, and the necessity of the solute atom in the former case being small compared with that of the solvent was fully realized.

With the aid of the recording pyrometer which he had designed, Roberts-Austen investigated, amongst other things, the surfusion of metals and alloys. He showed, for instance, that in those alloys of lead and tin which were slightly richer in lead than the eutectic, considerable surfusion could occur, a fact which was later to assume great significance in connection with the process of "modification."

Lacking modern resources such as X-ray methods of investigation, these earlier investigators were at times compelled to rely on specially devised techniques, some of which were of considerable ingenuity. As an example may be quoted the proof by Benedicks that the bars in the austenite-martensite structure were, in fact, magnetic. This he did by placing the polished and etched specimen between the poles of a powerful electromagnet in a bath of colloidal iron in acetone, the iron being attracted to the magnetic "needles" and thus producing a structure similar to that obtained by normal etching. It may be that, with the wider range of techniques at the disposal of the present-day worker, this spirit of ingenuity is now less evident, and, if this be so, metallography has suffered a serious loss.

The classical work of Benedicks on the marked effect which might be exerted by stress, both internal and external, on changes in metallurgical systems had just appeared when this Institute was founded. It was already well known that if a high-carbon steel is quenched from a high temperature, a partial retention of the austenite can be effected. This austenite, however, instead of occurring at the surface as would be expected, since the rate of cooling there is a maximum, is, in fact, found in the centre of the bar. Benedicks's demonstration that austenite could be retained, even in plain carbon steels, right up to the surface by the imposition of compressional stress is one of the most ingenious experimental results of early metallography. He did this by fusing the surface of the steel in a carbonaceous container, thus obtaining a shell of the white-iron eutectic, the rigidity of which during the subsequent heat-treatment of the composite bars inhibited the expansion which results when austenite transforms to martensite, and so prevented the change. This was not by any means, however, the first attempt which had been made to correlate the condition of strain with the transformations in steel, and Roberts-Austen, as far back as 1893, had shown that the change points in steel could be depressed by the application of pressure, and had studied the corresponding effects on Newton's alloy, the ternary eutectic of bismuth, lead and tin.

Diffusion in solid metals had been the subject of much work both in the ferrous and non-ferrous fields, by Roberts-Austen amongst others, and that such diffusion followed the normal Fick law was known. The diffusion of carbon in iron at very high temperatures had been investigated in detail by Arnold, and his results have not, so far as I am aware, been examined from the theoretical point of view even to-day. It was realized by some, although this was probably never published, that such solid diffusion involved a distortion of the crystal structure of the metal, and I well remember as a student a most satisfying explanation of the changes of structure brought about by normalizing an overheated steel, based on such lattice imperfections. The day of the "dislocation" had not yet dawned, but that the metallic crystals were, in most cases at any rate, far from perfect was well understood.

Age-Hardening

Although Wilm had not yet published his pioneer work on age-hardening, there were already, if eyes had been available to see it, clear indications of some such effect. In particular may be mentioned the fact, already well known, that the electrical and magnetic characteristics of soft-iron transformer cores changed in the course of time.

This "ageing"—and the term was already in use—was known to bring about a slow deterioration, resulting in reduced permeability and increased hysteresis. It was further known that these effects were not due to mechanical fatigue, but were the result of some change in the iron resulting from long-continued low-temperature treatment. The effect of both time and temperature on the hysteresis was examined by Roget, whose death was but recently reported, in 1898, and results were obtained identical with those of the classical researches on age-hardening. At as low a temperature as 65° C. and in a period of only 27 days, an increase of the hysteresis loss of over 53% was observed. As the temperature was raised, the rate of increase became greater, then a maximum was shown, and later a falling off, which became more and more rapid, whilst the

maximum in the curve fell progressively, until at 700° C. the effect was almost non-existent.

It was the same situation that we have come across repeatedly. The facts were there, but the explanation of the facts awaited more mature consideration, and further accumulation of knowledge drawn from a wide variety of sources.

The first experiments in powder metallurgy had been conducted long before the period with which we are here concerned, and with such experiments the name of Spring of the University of Liége must always be associated. Not only did he succeed in producing compacts even for brittle metals such as bismuth, but he showed that eutectics could be synthesized by pressure producing the quaternary eutectic of bismuth, lead, tin and cadmium with a melting point corresponding to that of the eutectic itself, although the most fusible of the constituents of which the powders were made did not commence to melt till a temperature some 130° C. higher had been reached. When such compacts were heated, Tammann, amongst others, obtained the clearest evidence of diffusion, a fact of which some recent workers seem to have been unaware.

The metallography with which we are concerned was in the main linked with physical chemistry; it might almost be defined as the physical chemistry of the metallic state; and the re-orientation with the formation of a metallurgical-physical bond was still in the future. The revolution which resulted from the introduction of X-ray techniques, for instance, can perhaps be best appreciated by reading a text-book of metallography written before 1914, when Bragg worked out the structure of copper. It may be argued, however, that metallography as a whole has lost substantially in this divorce from physical chemistry, and it is for this, amongst other reasons, that we welcome so whole-heartedly the magnificent text-book of metallography recently published by Professor Masing,[4] whom the Institute is honouring to-day.

Effect of Cold Work

Passing on now to the metallographic effects of cold work, the general outlines of the mechanism of plastic deformation, both by twinning and slipping, were common knowledge. So far as the former was concerned, and despite the fact that the day of X-ray investigation had not yet dawned, it was *known*, as a result, for instance, of the work of Osmond and Cartaud, that the twinning of iron took place on the (112) planes, and the crystallography of the Neumann lamella and of the Widmanstätten pattern in meteorites had been worked out by classical crystallographic methods. It was further known that the space lattice in which α-iron crystallizes was body-centred cubic. That the mechanical properties were a function of crystalline orientation was equally clearly appreciated. That metals and their alloys deform, in general, by a process of slip had been proved conclusively by Ewing and Rosenhain. This work was of fundamental importance not only in demonstrating the mode of deformation, but also in providing some of the most substantial evidence in support of the view that the grains in a metallic aggregate are truly crystalline. Although the process as they envisaged it is now known to be over-simplified, it was not long before the realization came that on the planes of slip fragmentation of the crystal must occur. Further, although the belief was unpublished, there were those who envisaged the slip not as a single, more or less catastrophic, fault but as a series of smaller movements extended only over atomic distances but on a correspondingly large number of planes.

No account of the state of metallographic knowledge in 1908 regarding the deformation of metallic crystals would be complete without some mention of the work of Beilby. As a result of simple but ingenious experimental techniques, fortified by a keen and inquiring mind, he had shown the effect of polish on a metallic surface and demonstrated that the surface layer was non-crystalline or amorphous. Later electron-defraction experiments probably did no more than confirm what Beilby had already demonstrated. His attempt to extend this idea to the slip planes of a metal when deformed was more hypothetical, but one aspect of this explanation, namely the temporary, so-called "mobile" condition, affords an explanation, at any rate no less convincing than some which have been subsequently proposed, of the effect of deformation on the elastic limit. That when plastic flow takes place the structure of the crystals is in a highly unstable state is beyond doubt, and it would be no surprise to me if some ingenious experimenter, sooner or later, demonstrates that Beilby was in fact right in his supposition, and that the *immediate* effect of cold work, so far from hardening the metal, is to soften it.

Internal Stresses

That most articles made from metals and alloys were a seat of internal stresses had long been known, and methods were already available for their measurement, in which field it would appear that Kalakoutsky may claim priority. The originator of the suggestion that the mechanical properties of metals could be improved by pre-stressing is uncertain, but the application of the process to gun tubes was suggested by Jacob in 1907, and probably to him the name "autofrettage" is due. Clearly, then, not only were the bad effects of internal stress only too well appreciated, but also the fact that these might, in suitable cases, be turned to good use, was not novel.

That such internal stresses were unstable even at ordinary temperatures was a matter of common knowledge. The "weathering" of castings before machining was frequently resorted to, to minimize distortion during the machining operation, and I remember well a Sheffield firm that "weathered" their nickel-silver ingots for 12 months before cold-rolling, in the belief that the treatment diminished edge-cracking and similar difficulties.

The absorption of energy by a metal due to cold working had been inferred by Osmond and Werth from their calorimetric studies, in which they found that cold-forged steel when dissolved in copper ammonium chloride solution gives out more heat than does the same material in the annealed state. In the case of cold-worked copper, on the other hand, they were unable to find a corresponding difference; this is not surprising in view of the fact that the measured rise of temperature was only about 0·1° C., whilst their experimental error was roughly one-third of this. In discussing these results, Howe says: "Such minute differences in heat evolution are less naturally ascribed to allotropism (as Osmond and Werth had suggested) than to unnoted differences in condition." "The shattering, stretching, or crumpling of resilient crystals, the creation of stress, macro- or micro-, are possible causes." So wrote Howe

in 1891, and these words are even more justified in the light of work which has been done on cold-worked structures since then. O'Neill had shown that cold hammering lowered the density of copper, as far back as 1861, and that a similar effect was to be observed with other materials was already known. "In short," says Howe, "the probabilities seem strongly against Osmond's theory (of allotropy), and in favour of the belief that cold work produces a special kind of change ..... roughly alike in the different malleable metals. What the nature of this change is I will not attempt to say, beyond surmising that it is essentially physical." Howe then dismisses the idea that the cold-worked material differs from the annealed only in the presence of stress, believing, as has already been mentioned, that some definite physical change has been produced in the crystals themselves. He was aware of the phenomenon which we should now call strain-ageing, and says that gentle heating, which should relieve the stress, may actually intensify the effect of cold working.

Preferred Orientation

Although the term "preferred orientation" was not introduced until much later, the effect was already well known. The first published account of the phenomenon appears to have been due to Stead, who showed that after certain types of mechanical and thermal treatment, the crystals in soft iron assumed a specific orientation such that the cube faces lay in the surface and at 45° to the direction of rolling. He published, in diagrammatic form, a typical example of a uniform crystalline orientation associated with a definite form of brittleness, still known as "Stead's brittleness." In his own words "just as light produces a latent invisible picture on the photographic plate, so the act of rolling steel sets up a latent disposition to crystallize in definite directions." Surely as clear a definition of preferred orientation as, in the absence of that term, could be expected.

I am assured by Dr. Maurice Cook that the effect must also have been known in the non-ferrous alloys ever since cups were first made by pressing (by the ears which it causes), although it was not associated until many years later with a definite crystalline structure.

The excessive crystal growth which results from small amounts of strain followed by an appropriate annealing treatment had also been observed by Stead in the case of iron. It is almost certain that a similar effect must have been equally well known, by those in the industry, to occur with non-ferrous metals and alloys; and single metallic crystals had been cleaved from such coarsely crystalline samples and their properties examined. It was left to Carpenter and Elam, however, to devise, on the basis of such knowledge, their strain-anneal technique for the routine production of single crystals.

I may perhaps be pardoned for mentioning the property now known as damping capacity, a tool increasingly useful in metallographic research. Although that designation was not used until the nineteen-thirties, the ability of a solid to dissipate mechanical vibrational energy had been appreciated for a long time. Weber, in 1837, described work on the elasticity of silk fibres, in which he stated that the decay of amplitude of a vibrating system is *not* due entirely to air friction, but is partly the result of mechanism operating within the elastic parts of the system. He further stated that a relationship must exist between the logarithmic decrement and the elastic after-effect which is observed, for example, in galvanometer suspension wires.

In 1865 Lord Kelvin published results of the measurement of the viscosity of solid metals, derived from the fall of amplitude of a system in torsional vibration; he noted the high rate of decay for zinc, compared, for example, with that for copper, silver and aluminium. Previous analysis of the thermo-elastic effect allowed him to state from fundamental considerations that here was a mechanism which must of necessity, under certain conditions, endow even a perfect isotropic crystal with what we now call damping capacity. Another important conclusion drawn from his experiments was that the variation of damping with frequency differed from that to be expected if the damping forces obeyed the same law as that which holds for a classical viscous fluid.

There is one field in which factual knowledge was almost as complete fifty years ago as to-day. This is the inter-relation between magnetic characteristics and mechanical deformation. The remarkable, and often *extremely* complex effects of both elastic and plastic deformation on magnetic properties had been examined by a large number of workers. As an example may be cited the transitory circular magnetization produced when a longitudinally magnetized wire is suddenly twisted, or when a longitudinal magnetizing force is suddenly applied to a rod in a state of torsion, and it is of interest that it was in connection with these tests, in which the magnetization lagged behind the twist, that the word "hysteresis" seems first to have been used. This is connected with the Wiedmann effect, and has subsequently been re-examined and related to damping characteristics. There is here an almost inexhaustible mine of information which still awaits detailed examination in the light of modern magnetic and deformational theory. During the last forty years or so, explanations based on the "domain" theory of magnetism have clarified considerably our understanding of these phenomena, but much still waits to be done.

Such then, was the broad state of metallographic knowledge when this Institute was formed. The foundations were built on rock and have withstood the storms of time. Is the superstructure equally strong?

Whole sections of the science, i.e. the chemical aspects, have perforce been left out, and many names of illustrious workers are omitted.

Well may it be said of such as these:

> "Let us now praise famous men, and our fathers that begat us.
>
> "All these were honoured in their generations, and were the glory of their times."

Have I overpainted the picture? Well, read the first edition of Dr. Desch's "Metallography," *published* early in 1910, and I think, like the Queen of Sheba, you will agree "Lo! The half was not told me!"

REFERENCES.

1 Lumsden, J., "Thermodynamics of Alloys," London, 1951 (Institute of Metals).
2 Arnold, J. O., *Proc. Inst. Civil Eng.*, 1895–96, **123**, 127.
3 Roberts-Austen, W. C., *Proc. Inst. Mech. Eng.*, 1893, 102.
4 Masing, G., "Lehrbuch der allgemeinen Metallkunde," Berlin, 1950 (Springer-Verlag).

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Metal Casting Methods

I—Some General Considerations

By J. B. McIntyre, M.Sc., A.I.M.

Lecturer, National Foundry College, Wolverhampton.

Most of the common metals are originally melted and cast, whether they are used in the as-cast state or subjected to mechanical and/or thermal treatment. In this series of articles, the author deals with the various methods employed in the production of shaped castings and of ingots for subsequent working.

METALS, which form the greater proportion of the chemical elements, are characterised by certain physical properties which may be controlled to a large extent by the presence or absence of comparatively small amounts of impurity. Copper is a typical example, the electrical conductivity being affected by comparatively small amounts of phosphorus, and the strength reduced to a low level by little more than a trace of bismuth. Several metals which previously exhibited properties deviating from the general standard (notably magnesium, zinc and titanium) have recently been produced in the super-pure condition, and the effect of traces of impurity has thereby been established.

Modern production methods have enabled certain little-used metals to be more widely applied than was formerly possible, and beryllium, zirconium, tantalum and lithium can be included in this group. The principal metals of industrial importance remain, however, iron, copper, zinc, aluminium, magnesium, nickel, tin and lead. The importance of these materials is related to their availability, which may be expressed in terms of the extent of their occurrence and of the ease with which they may be extracted and processed into a useful form. This point is illustrated by aluminium and magnesium, which have been more widely applied in industry since improved extraction techniques were developed.

Quality of Cast Metals and Alloys

Most of the common metals are melted and cast before use, although there are exceptions, such as tungsten, which are prepared by special techniques in which the metal is not melted. The ideal cast metal or alloy should conform to the following requirements :—

(1) uniform composition and fine-grained structure ;
(2) good surface finish ; and
(3) freedom from internal unsoundness and inclusions.

These requirements are not obtained from any casting process since the necessary conditions are not always compatible with each other.

Uniformity in chemical composition and structure is influenced by the type of alloy being cast. Pure metals are obviously not liable to segregation, but the grain size of the cast metal may vary considerably, and variable grain size in material intended for wrought applications is generally considered to be undesirable. It has also been established that the response of cast material to subsequent heat-treatment operations is influenced by the grain size.

Freedom from internal unsoundness must be a compromise between economy and the practical application of the product. The mechanical properties of cast material are directly influenced by the degree of soundness obtained, and freedom from porosity in any of the recognised forms is theoretically required if the maximum properties are to be obtained. Cast material is rarely produced in the absolutely sound state, though the properties obtained are nevertheless adequate. The existence of unsoundness due to various causes has been recognised for many years, and has been utilised in several casting processes to improve the economic yield. For example, in the production of tough-pitch copper ingots, rimming steel ingots, and in certain aluminium-alloy die-castings, a controlled gas content is maintained in the metal or alloy concerned, which effectively restricts shrinkage by dispersion. Gas unsoundness is present in most cast metals and alloys, though non-ferrous materials of the copper-base, nickel-base, and aluminium-base types have received most attention in the literature dealing with this subject. Ferrous material is also liable to this type of unsoundness, though the results are not usually so marked.

Much variation in microstructure and macrostructure can be seen in alloys which have been cooled at a non-uniform rate. The cooling rate is very important, and alloys such as cast iron, aluminium bronze, tin bronze and steel are profoundly affected by variation in the cooling rate. It would appear that uniformity in microstructure and macrostructure is best obtained if the whole metal mass under consideration is cooled at a constant rate. This is difficult when the casting is of simple and uniform shape, and is practically impossible when shaped castings of non-symmetrical contour are considered : sand castings are usually of the latter type. Cooling is mainly due to heat abstraction by the mould material and, as the latter becomes heated, heat transfer is decreased appreciably. Non-symmetrical castings may have many different section thicknesses which render the cooling problem even more complicated.

Shrinkage

Most metals and alloys shrink to some extent when cooled from the liquid to the solid state. Metals such as bismuth and silicon, which apparently expand, and alloys such as grey cast iron, which appear to shrink little on solidification, are exceptional. The shrinkage which occurs in commercial alloys presents a serious problem in practice, and is mainly responsible for the very large number of casting methods now in use. The term shrinkage is applied to the reduction in volume occurring as a mass of liquid metal is cooled, and includes the considerable volume reduction which accompanies solidification. Shrinkage should be distinguished from

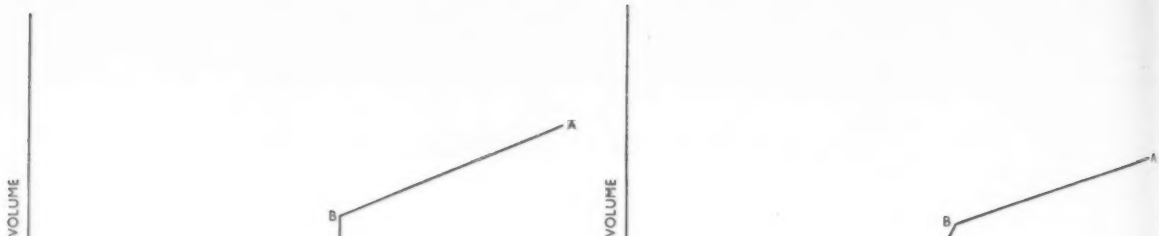


Fig. 1.—Volume changes occurring during cooling of a mass of liquid metal: pure metals and eutectic alloys on the left and solid-solution type alloys on the right. From A to B the metal is wholly liquid, solidification taking place from B to C and solid contraction from C to D. The liquid and solidification shrinkages are compensated for by the use of risers, whilst provision is made on the pattern to allow for the solid contraction.

contraction, which is the reduction in volume which results from the cooling of a given mass of solid metal. Shrinkage values for many metals have been established and the volume changes which take place on cooling liquid metals and alloys are shown diagrammatically in Fig. 1. Pure metals and alloys of eutectic composition solidify at a constant temperature in each case, while alloys of the solid-solution type tend to freeze over a range of temperature. The manner of solidification has a profound effect on the soundness of cast material, and many devices are adopted to counteract shrinkage effects. In principle, the production of sound castings in pure metals or eutectic alloys is relatively simple, provided that a constant supply of hot liquid metal is available to fill shrinkage cavities as they form during the freezing process. The feeding of shrinkage cavities as they occur in castings is facilitated if the molten metal is chilled from the base so that heat is abstracted downwards.

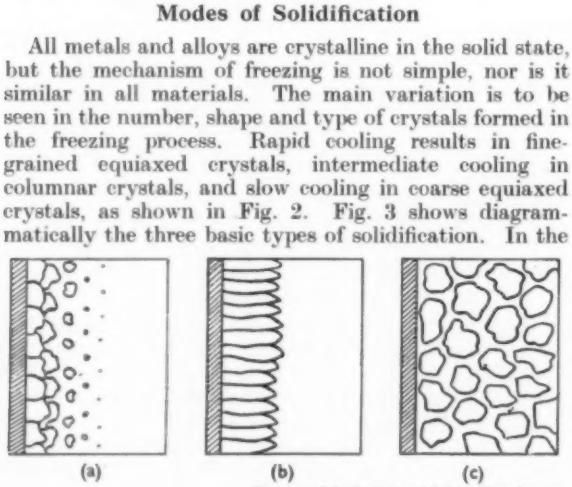
Modes of Solidification

All metals and alloys are crystalline in the solid state, but the mechanism of freezing is not simple, nor is it similar in all materials. The main variation is to be seen in the number, shape and type of crystals formed in the freezing process. Rapid cooling results in fine-grained equiaxed crystals, intermediate cooling in columnar crystals, and slow cooling in coarse equiaxed crystals, as shown in Fig. 2. Fig. 3 shows diagrammatically the three basic types of solidification. In the shell type (*a*) all the crystals are rigidly joined forming a continuous wall, whilst in the skeleton type seen in (*b*), the crystals are rigidly joined at the contact points, with liquid in the interstices: all the crystals are unconnected and surrounded by liquid in the friable type (*c*).

In the ideal case, a solid casting may readily be obtained by top pouring at extremely slow rates, as this enables the layers of fresh liquid metal to be drawn into the shrinkage cavity, or pipe, as it is formed. Such pouring rates are not economic, however, nor are they practicable in most cases.

Most castings tend to be cooled from the sides as well as the bottom of the mould, and crystal growth is thereby complicated. Crystals may grow simultaneously from all sides which are in contact with the mould wall, and may "bridge" in the centre of the casting, causing part of the shrinkage cavity to be excluded from further supplies of feeding metal.

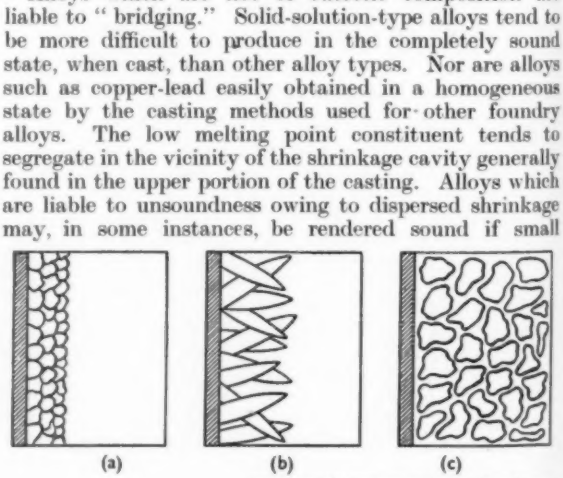
Alloys which are not of eutectic composition are liable to "bridging." Solid-solution-type alloys tend to be more difficult to produce in the completely sound state, when cast, than other alloy types. Nor are alloys such as copper-lead easily obtained in a homogeneous state by the casting methods used for other foundry alloys. The low melting point constituent tends to segregate in the vicinity of the shrinkage cavity generally found in the upper portion of the casting. Alloys which are liable to unsoundness owing to dispersed shrinkage may, in some instances, be rendered sound if small



Courtesy of the Institute of British Foundrymen.

(a) Fine equiaxed grains (rapid cooling).
(b) Columnar crystallisation (intermediate cooling rate).
(c) Coarse equiaxed grains (slow cooling).

Fig. 2.—Cast structure formation (after Scheuer).



Courtesy of the Institute of British Foundrymen.

(a) Shell type (continuous solid wall).
(b) Skeleton type (crystals in partial contact).
(c) Friable type (loose crystals surrounded by liquid).

Fig. 3.—Basic types of solidification (after Scheuer).

additions of lead are made to the original alloy. It is believed that lead tends to segregate in such alloys, filling up the internal fissures which cause leakage under pressure. Certain tin-bronze castings are more easily produced when lead-bearing material is used. High-lead alloys should be subjected to controlled cooling conditions in order to secure adequate distribution of the low-melting-point material. Rapid cooling is advantageous in such cases.

Ingots and Shaped Castings

Casting methods may be broadly divided into two sections :

(1) Ingot production for subsequent remelting or processing into wrought form ; and

(2) Casting into shaped moulds to produce components finding application in engineering or other work.

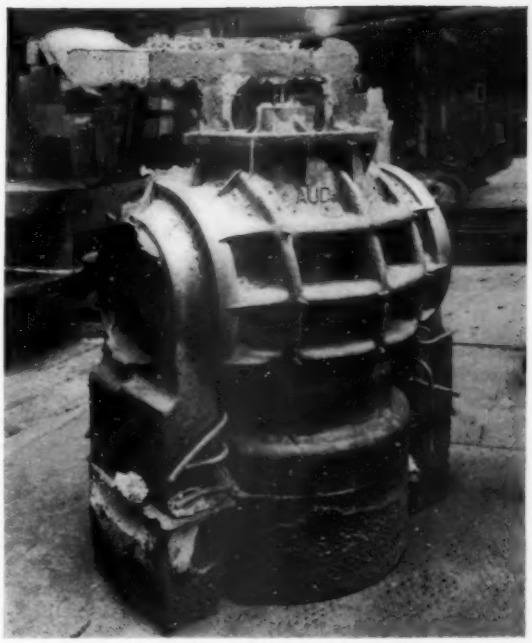
The greater proportion of all metal cast is subsequently wrought, since this is the cheapest large-scale production method. Alloys such as cast iron and the more complex heat-resisting alloys may only be cast into shape, owing to their lack of ductility or machinability under normal conditions. The production of shaped castings and that of ingots intended for mechanical working or remelting are regarded as being separate, although it is sometimes economic to substitute one for the other or even to combine the two methods. For example, increased production of forged components may be obtained if the initial shaping processes are replaced by a single casting operation, and the casting finished with a limited amount of forging. Processes have been suggested which involve the pressing of shaped components from pasty metal or alloy contained in a die.

Casting and forging, pressing or extrusion, may sometimes be considered as alternatives for the production of metallic articles. The economic factor will be an important feature in every case, and the size of the component, together with the quantity required, will influence the final decision. Articles of intricate design, and modern engineering components in alloys of complex composition, are usually cast into shape. Ingots and shaped castings have many similar characteristics, though the subsequent application of each may be quite different. Both products are produced by pouring liquid metal or alloy into a shaped cavity called a mould, and each may vary from a few ounces to over 200 tons in weight. Similar problems are encountered in each case : they may be divided into those due to the mould material, and those which can be ascribed to metallurgical factors alone.

The variations experienced in casting operations are mainly due to the thermal properties of the metal or alloy and the mould material used ; and to such features as gas solubility effects and crystal growth. In all cases, the size and shape of the metal mass has a major effect upon the properties obtained.

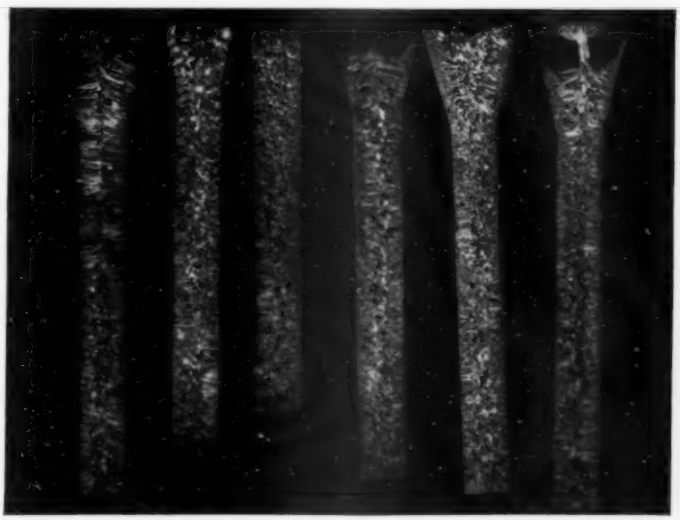
Grain Size and its Control

Feeding capacity, pressure tightness, general mechanical properties and resistance to hot tearing are all reduced by large grain size in cast material, and various techniques are established in the foundry industry to avoid coarse grain size. Many common foundry alloys are subjected to a specific treatment whilst molten in order to promote grain refinement, since the favourable influence of hot-working processes cannot usually be applied in



Courtesy of David Brown Foundries Company.

Fig. 4.—Steel valve casting (inverted) before fettling, showing running and feeding arrangements needed for alloys of high shrinkage.



Courtesy of Wednesbury Technical College.

Mould dressings (left to right) : bone ash ; untreated ; resin and charcoal ; lamp black ; machine oil and charcoal ; and machine oil and wheat flour.

Fig. 5.—Photomacrographs of 70 : 30 brass, showing the effect of mould dressing on grain size.

the production of shaped castings. Certain aluminium alloys are treated with titanium or columbium in order to induce grain refinement, while magnesium alloys containing aluminium should be improved in this respect by the addition of small amounts of carbon. Zirconium is now well established as a potent grain-refining agent in magnesium alloys, and iron has also been used for this purpose. The latter element appears to promote grain refinement in copper-base alloys, though little precise information has been published in this connection.

The photomacrographs in Fig. 5 show a series of test bars poured from a single melt of 70 : 30 brass in order to compare the effects of mould dressings upon grain refinement. A tundish arrangement and a pouring temperature of 1,150° C. was used in each case. Each bar was poured in a cast iron mould of one inch diameter, and a single dressing was applied to each of five moulds ; one mould was left untreated in order to facilitate comparison. The photomacrographs shown are those of bars cast in moulds treated with the following materials (left to right) : (1) bone ash ; (2) untreated ; (3) resin and charcoal; (4) lamp black; (5) machine oil and charcoal; and (6) machine oil and wheat flour. It will be seen that the first and fourth show little variation in grain size from that present in the untreated bar. The former were treated with non-reactive dressings, while the latter was produced in an untreated mould. Bars numbered three, five and six show some grain refinement, and this is no doubt due to the flaming dressing used in each case. Minute particles of carbon are always present in such cases, and probably exert a nucleating effect upon the alloy. Grain refinement in such cases is usually ascribed to gas effects, yet since the latter are comparatively short lived, it is likely that the more stable carbon particles are the nucleating agents responsible.

Steels of high chromium content respond favourably to grain refining treatment with titanium or nitrogen. The optimum grain size obtained in cast material is a function of the alloy concerned, and the finest grain size obtainable in one alloy type may be considered coarse when compared with other alloys.

Many workers have investigated the phenomenon of grain refinement, and various theories have been advanced, many of which are convincing though not capable of general application to all alloys. Nucleation processes are thought to be responsible, but the mechanism has not yet been established. In isolated instances coarse grain size may actually be desirable.

Recent British work has shown that large grain size in Alnico type cast magnet alloys can promote favourable magnetic properties. In such cases substantial alloying additions of nickel or tantalum are made to the superheated molten base alloy, and a desirable columnar crystal structure obtained by uni-directional chilling in a pre-heated refractory mould.

Water Cooled Magnet Charger

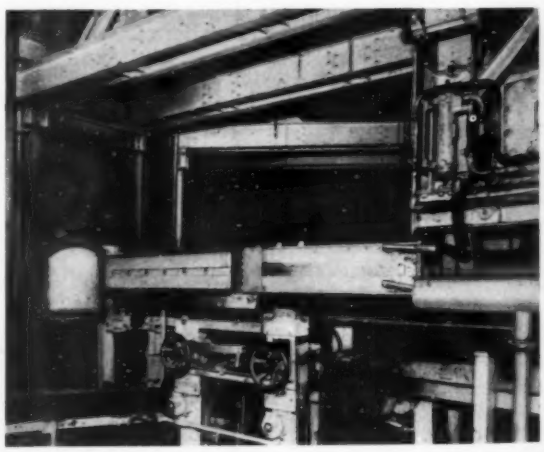
Interesting Rotary Hearth Furnace Machine

AT the Works of Tubes Ltd., Birmingham, a water-cooled magnet, designed and constructed in the Witton-Kramer Electric Tool and Hoist Works of The General Electric Company, Ltd., has recently been commissioned for charging billets into a rotary hearth furnace, the furnace and the charging and discharging machines being built by the Salem Engineering Co., Ltd., Milford, near Derby.

The magnet, which is wound for service on a 220 volt D.C. supply, weighs approximately fifteen hundredweights, and is capable of handling billets ranging from 3½ in. to 4 in. diameter up to 5 ft. long. A selenium metal rectifier fed from the 400/440 volt, 3-phase, works supply provides direct current for the magnet which is controlled by a master controller and contactors.

The generally recognised method of charging rotary hearth furnaces is by means of a machine provided with a mechanically controlled extension arm which is fitted with grips to handle the billets, so that this installation represents a new and interesting extension to the field of service of the lifting magnet. The lifting magnet offers two important advantages. First the billets can be charged with their ends touching, thus giving a better hearth loading, and secondly, as more than one billet can be picked up at a time, the furnace has to be charged less frequently resulting in less wear and tear on the charging machine and reduced heat losses.

As the lifting magnet has to be inserted into the furnace, its design and construction must be such that it will withstand temperatures of the order of 1,000° C. without detriment. Satisfactory performance of the magnet at these temperatures has been achieved by



providing water jackets along each side of the magnet and extension arm of the charging machine, independent water circulation being provided for each cooler.

The cold billets to be charged into the furnace may vary in length from one to five feet, and the continuity of the poles over the whole length of the magnet permits billets of the same diameter but of different lengths being handled simultaneously.

Acknowledgments are made to Tubes Ltd., and to the Salem Engineering Co., Ltd., for permission to publish this information and to reproduce the photograph of the installation.



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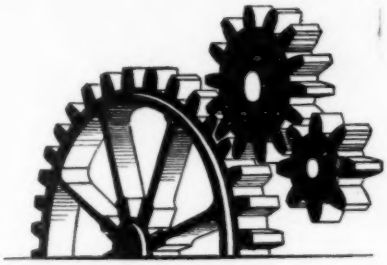
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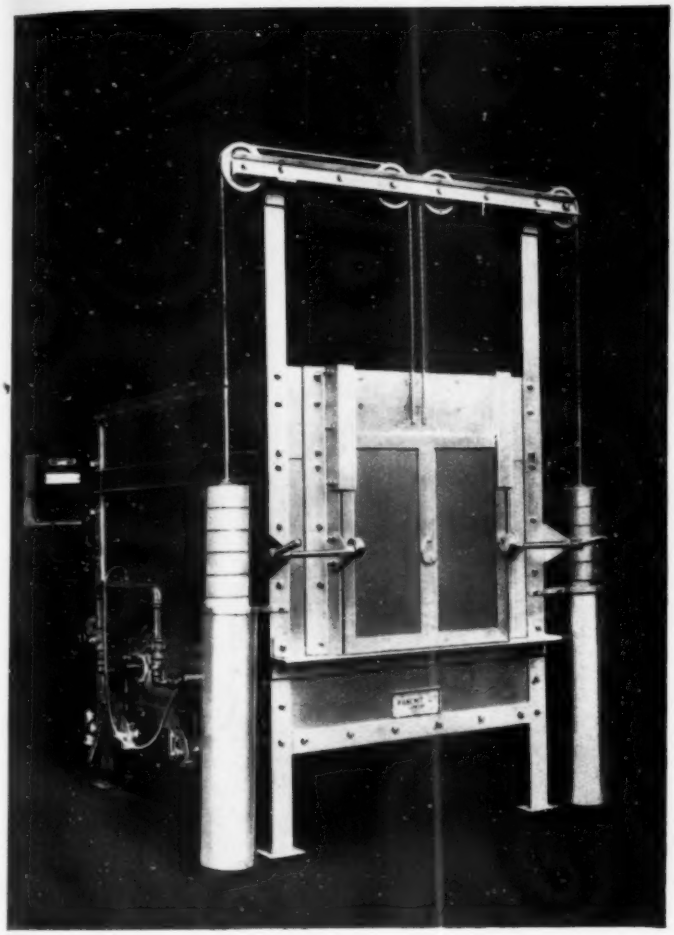
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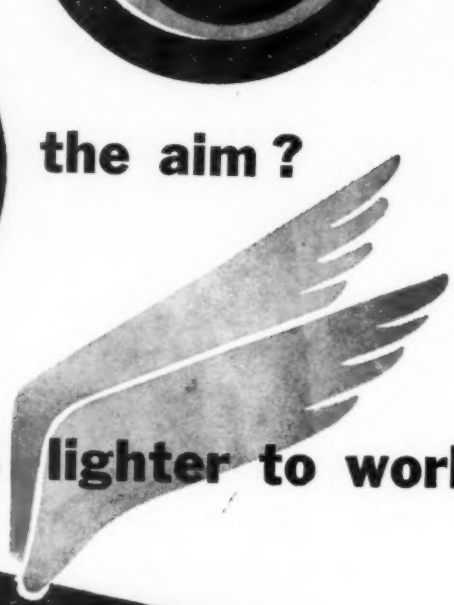


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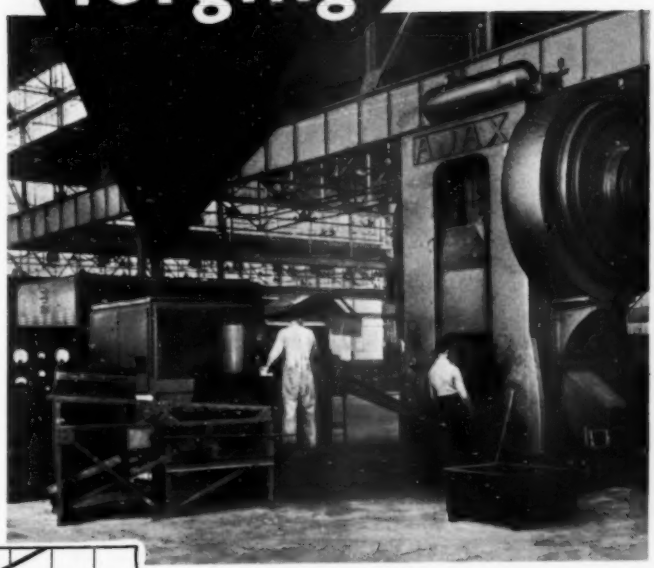
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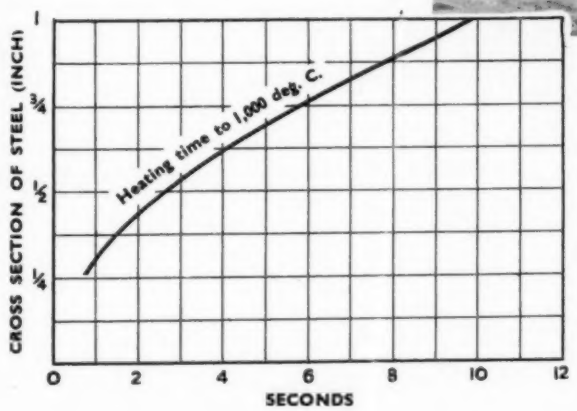
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Great savings in costs and production time can be made by using EFCO-TOCCO high-frequency induction heating for forging. Consider some of the advantages that are offered: cold blanks are heated in a few seconds—the curve below shows the times for heating to 1,000°C.; only a few minutes are required for restarting from cold; the temperature of heated billets is automatically controlled; there is virtually no scale; this saves material and reduces wear of dies; there is no heat or fumes since heat is developed only within the work; less floor space is required than for furnace heating; hot billets are fed to the press by chute or conveyor at a constant rate for mass production.

One example of the speed of output is that a turntable heater station rated at 150 kW for heating steel pins for bolt forging will deliver 2,000 pins of ¾" dia. an hour.



Induction heater delivering continuous supply of hot billets to a forging press.
Courtesy of John Garrington & Sons, Ltd.



EFCO-TOCCO INDUCTION HEATING

Please send for detailed information

ELECTRIC FURNACE CO. LTD
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Electric Resistance Furnace Co. Ltd.
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A revolution in cutting oils—

SOLUBRIOL VG★

the new Soluble Oil with the lubricating properties of the best Neat Oils

SEND FOR THIS PAMPHLET TODAY!



A soluble oil with the film strength of neat oil seems like the answer to a lot of machining problems. Here is the story of a recent development in cutting oils

Better Finish and 20% longer tool life are said to have resulted from using soluble oil containing a dispersion of calcium soap when broaching the bores of steering worm blanks made from 3% nickel-chrome alloy steel. Previously cutting Fluids and leadless glaze was used

METALLIC SOAP ADDS FILM STRENGTH TO SOLUBLE OIL

N. E. F. HITCHCOCK* and H. M. WHITE
C. C. Wakefield & Co., Ltd.

THE main functions of a cutting oil are (a) to carry off heat generated in separating the metal chip from the work, and so avoid undue temperature rise, (b) to lubricate the chip as it slides over the face of the tool, and so reduce frictional heat and abrasive wear. In choosing between soluble and neat oils for any particular application it has to be decided which of these two functions is the more important in that case. For neither type of oil has equal qualities in these two respects.

Chief advantage of soluble oil emulsions is that their major constituent is water. Since the specific heat of water is approximately twice that of neat oil, and as its thermal conductivity is about four times as great, it is that soluble oil emulsions are ... than neat ... choose where effective cooling is the main requirement.

Neat oil is, however, a better lubricant, and it tends to cling more tenaciously to the surface of the tool even under high frictional loads, and that reason it is frequently preferred where good lubrication is essential.

Unfortunately, there are many ... of cases, involving heavy ... tough material, where ... lubricating attributes are of equal importance. In other words, where an emulsion with good lubricating ... is wanted.

Recent experience ... good results in cases ... conditions are being ... soluble oil emulsion ... addition of a me...

...ith their inherent cooling ... used, an ... film would be intrinsically thicker than ... ...ts, an ... ...lop ... ...ve ... ...ve ... ...ve

THE BRITISH INDUSTRIES FAIR

Engineering Exhibits at Castle Bromwich

The decline of the sellers' market gave added importance to the displays of British goods at the Castle Bromwich, Olympia and Earls Court sections of the British Industries Fair last year, and the events of the past 12 months have done nothing to diminish the necessity for increasing our exports to the markets of the world. Apart from acting as a national shop window, the B.I.F. provides opportunities for personal contacts to be established with home and overseas buyers. In this survey of exhibits, attention is mainly directed to metallurgical aspects of the Engineering Section at Castle Bromwich.

THIS year's British Industries Fair is the 32nd in the series which started in 1915, and for the last few years, each succeeding Fair has brought with it arguments for and against its being held annually. This year, in fact, rumour was so strong that the Coronation Fair was to be the last that an official denial was issued. There is, however, in existence an Exhibitions Advisory Committee which is studying the best way to organise the Fair, but it has already informed the President of the Board of Trade that it should continue to be held. It is, of course, rather difficult to assess the results of participation in the Fair, as impressions created in the minds of buyers may only bear fruit some months, or even years, later. No Fair has any real existence apart from its exhibitors, for without their support it cannot survive. That the B.I.F. survives is evidence that it meets a demand, and further confirmation of the belief held by many firms in the value of participation is shown by the fact that they occupy the same stands year after year.

In the space available, no more than a brief indication can be given of the exhibits at Castle Bromwich which are likely to be of interest to those concerned with the production and use of metals in their various forms. In the following pages the exhibits are, in the main, classified according to their nature, the name of the exhibitor being given in the text along with the stand number. Almost all the exhibits referred to will be found in Sections C and D.

Wrought Steel

The story of the production of steel within the various works controlled by THE UNITED STEEL COMPANIES will be told by the use of enlarged colour transparencies on Stand D.519/416. Fifteen in number, these will show the methods employed to manufacture such diverse products as acid Bessemer steel at Workington, Cumberland; fine wire at the Samuel Fox branch; steel railway wheels at Steel Peech and Tozer; the cogging of steel ingots at Appleby-Frodingham; and the production of steel by the electric arc or open-hearth processes. The main stress of the display will be laid upon the production of "Silver-Fox" stainless steels at the Samuel Fox branch. This will be illustrated, not only by means of the colour transparencies previously referred to but also by actual materials showing some of its many forms, finishes and uses. As usual, technical representatives will be in attendance throughout the period of the exhibition to deal with visitors' queries.

Some months ago a 270-ton ingot, the largest ever cast in the Commonwealth and the first of a number which are to be forged under a 7,000-ton electro-hydraulic press into one-piece high-pressure boiler drums, was cast at the Sheffield works of ENGLISH STEEL CORPORATION, LTD., whose stand (D.541/438) will be dominated by a full size model—26 ft. long × 10 ft. 4 in. across its largest octagon section. This model will be symbolic of the heavy forging side of the Corporation's activities, whilst smaller forgings will be represented by highly-finished crankshafts and jet engine discs made from high quality alloy steels. Of special interest to engine builders will be crankshafts forged by the C.G.F. (continuous grain flow) process. These embody all the advantages of a drop forging, but can be made in sizes beyond the scope of any British drop forge. There will also be a display of coil and laminated springs and torsion bars.

Some of the greatest developments in steel during recent years have taken place in the field of stainless and, more particularly, heat-resisting steels, as a result of the impact of the jet engine and other forms of gas turbine. Important contributions to this progress have been made by FIRTH-VICKERS STAINLESS STEELS, LTD., who will be showing, on Stand D.419/318, corrosion- and heat-resisting steels in the form of sheet, bar, strip, forgings and castings.

Railway track engineers will be interested in Stand D.503/400, where EXORS OF JAMES MILLS, LTD., will display specimens of their rail track fastenings. The Aladdin rail and wheel flange lubricator for reducing wear on the curves of railway track will also be exhibited. The display will include a range of bright drawn steel bars (of which the Company are the largest makers outside the United States), and components made in Ledloy high-speed machining steel, together with keys, cotter pins, taper pins and Mills' patent grooved pins and studs.

On Stand D.225/126, the DARWIN GROUP, which includes DARWINS, LTD., ANDREWS TOLEDO, LTD., WARDSEND STEEL CO., LTD., and ANDREWS TOLEDO (WIRE ROD), LTD., large illuminated colour photographs will depict some of the various processes in the production of Darwin products, whilst three-dimensional colour photographs will add life-like interest to the display. The products on view will include carbon and alloy steels for the aircraft, automobile and engineering industries, castings, permanent magnets wire rod and tools.

Well known in the field of rolled steel products, LEE OF SHEFFIELD, LTD. (D.530) will be showing a selection of bright steel bars, cold-rolled steel strip, high grade steel wire, stainless steel strip and wire—all principal

manufactures of the company—along with a selection of articles made from stainless steel.

Stand D.407/306, which will be occupied by RICHARD THOMAS & BALDWINS, LTD., will act as a meeting place for customers to discuss their requirements and problems related to the Company's products, which include steel sheet, tinplate, and other flat-rolled and merchant mill products in light alloy and alloy and electrical quality steels.

Stainless steel in all forms and finishes, with particular emphasis on polished material, which is a speciality of PADLEY & VENABLES, LTD. (D.525/422) will be shown by that Company, the exhibits including sheet, strip, bars, tubes, sections and wire, together with finished articles made from stainless steel.

Attention is also drawn to the stands of J. B. & S. LEES, LTD. (D.329) makers of hot rolled and bright cold rolled steel strip; GUEST KEEN & NETTLEFOLDS (MIDLAND), LTD. (B.629/526), who will be showing cold rolled strip; and the BROCKHOUSE ORGANISATION (D.405/304), whose exhibits will include drop forgings and cold rolled sections.

Ferrous Castings

On the EDGAR ALLEN stand (D.536), the steel foundry department exhibit will include two groups of castings; one covering electric traction motor castings, and the other steel castings for excavators. The largest electric traction motor casting will be a frame weighing a little over 15 cwt. Other castings of this type will include bearing boxes, axle caps, brush holder supports, end plates, sealing rings, arm spiders and commutator hubs. The largest excavator casting will be an eccentric weighing approximately 33 cwt. Other excavator castings displayed will include blanks, fairlead frames, barrels, racks, stops, swivel blocks, traction bearings, bearings caps, rollers and a clevis.

Reference has already been made in the previous section to the fact that stainless steel castings will be shown on the stand of FIRTH-VICKERS STAINLESS STEELS, LTD. (D.419/318), the exhibits including ordinary static castings, centrifugal and centri-die castings and precision castings.

The introduction of new mechanised plant at the Tipton foundries of HALE & HALE (TIPTON), LTD., has considerably improved the delivery position, and for the first time since the war the firm will be able to offer to B.I.F. buyers early delivery of most types of Blackheart malleable iron castings. Besides the normal Blackheart malleable, the foundries are now in full production of Permalite, a special purpose high-duty iron, developed in the Hale laboratories; which has a tensile strength of 33–35 tons/sq. in., a yield strength of 20–22 tons/sq. in., an elongation of 6–8%, and a bend of 90°. Several newly developed products will be featured this year on Hales' stand (D.609/508) including the Barslide pitprop head and special malleable iron clips for use with the tram-rail type of steel sleeper on light gauge mine railways.

Blackheart malleable castings will also be featured on Stand D.709 (FOLLSAIN-WYCLIFFE FOUNDRIES, LTD.) where the exhibits will also include a number of examples of castings in C.Y. alloy. This material is not intended for resistance to shock, but its tensile strength at 30–35 tons/sq. in. makes it stronger than cast iron. Its main feature is its abrasion resistance; it is claimed to outlast chilled iron by 3–5 times.

Further examples of malleable iron castings will be displayed on the stand of LEY'S MALLEABLE CASTINGS CO., LTD. (D.513/410), indicating their use in the automobile, agricultural, electrical and general engineering trades. These castings are available in normal blackheart malleable and Lepaz pearlitic malleable.

A steel casting, representative of the products of JARROW METAL INDUSTRIES and based on many years experience in high quality steelfounding, will be shown on Stand D.235/136, which is shared with the associated Company, SIR W. G. ARMSTRONG WHITWORTH & CO. (IRONFOUNDERS), LTD.

Prominent among the display of FERRANTI castings on Stand C.615/514 will be special types of iron produced in the Ferranti foundry, including NOMAG, NOduMAG, spheroidal graphite iron and high duty iron. NOduMAG is the ductile version of the non-magnetic austenitic NOMAG, and has a tensile strength of 24 tons/sq. in., a yield point of about 20 tons/sq. in. and an elongation of 5–10% in the unannealed condition. The light repetition castings on view will illustrate the high degree of dimensional accuracy and finish on Ferranti castings.

JOHN HARPER & CO., LTD., are well known in the field of iron castings, one of their lines being the production of castings in Meehanite, but their B.I.F. stand (A.336) is in the hardware section, and the exhibits will comprise new lines made by the Company and incorporating castings. They will include an oil convector radiator, a leaf spring scale, a griller hotplate, and a gas-heated towel rail.

As might be expected from the name of the Company, H. & F. PRECISE CASTINGS, LTD., will have on view on Stand A.327/226 some 75 precision castings in 10 different alloys. On the ferrous side there will be general engineering castings in various steels to replace forgings and parts machined from bar, together with blading and other castings in heat resisting alloys for use in gas turbines. The display will be completed by a selection of castings to illustrate the application of precision castings to prototype work, Stellite castings to resist abrasion, and dentures and surgical castings in chrome-cobalt alloys. A wide range of Stellite castings shown by DELORO STELLITE, LTD., on Stand D.402 will include numerous examples of those of the precision type.

Special heat-resisting and corrosion-resisting castings will be shown on Stand D.225/126 by the DARWIN GROUP, whilst other stands featuring ferrous castings—in these cases in grey iron—will include those of the BROCKHOUSE ORGANISATION (D.405/304) and T. & J. BRETTELL, LTD. (D.149).

Non-Ferrous Metals

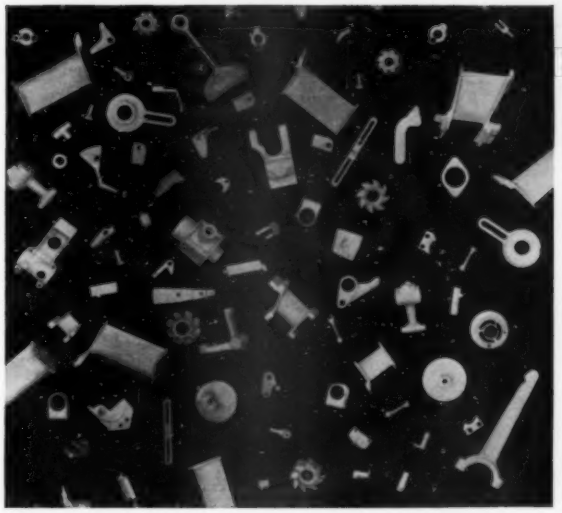
THE COPPER DEVELOPMENT ASSOCIATION on Stand D.232, will, by means of photographs and display examples, invite users of copper and copper alloys to make full use of all C.D.A. services, which are available free on request. The authoritative technical books published by the Association on applications of copper in many industries, and on the properties of copper and its many useful alloys, will be prominently displayed. Much of the work of the C.D.A. is done by letter and by telephone, the enquiries having the personal attention of the highly qualified technical staff, some of whom will be in attendance on the stand each day during the Fair.

For many years THOMAS BOLTON & SONS, LTD. (D.518), have played a leading part in the development and manufacture of copper and its alloys for use in the electrical and other industries. Just how long it is since the foundation of the firm will be emphasized by the theme of the stand — During Nine Reigns — for the date was 1873, in the reign of George III. A 10 in. wide by 1 in. thick drawn section busbar will be bent to form a portal over one of the entrances to the stand's office and other electrical exhibits will include Combarloy, a special alloy for commutator segments, rail bonds for electric traction, 2- and 3-pole equaliser bars, rotor and stator end rings, H.C. busbars, wire and strip in copper, brass and bronze, and trolley wire. Other exhibits will include tubes, extruded and drawn sections, machined parts and copper printing rollers for the textile trades. "Bush" brand chill-cast phosphor bronze solid and cored bars, and tungsten carbide drawing and extruding dies made from B.T.H. "Ardoloy" complete the display.

In addition to general displays of sheet, strip, rod, extrusions, tubes, wire and fabricated metal sundries in copper, aluminium and their alloys, together with specimens of condenser and locomotive firebox plates and copper rollers for textile printing, the METALS DIVISION of IMPERIAL CHEMICAL INDUSTRIES, LTD., will feature, on Stand D.409/308, exhibits showing the many applications of its wrought non-ferrous metals in building and transport. Domestic water, gas and sanitation services will be represented by light gauge copper tubes and fittings, whilst Kuterlon long length copper tube suitable for underground water and gas supplies and for radiant panel heating will also be featured. Other building developments will include aluminium for roofing; Kudampro copper damp course strip; corrugated copper joint strip for concrete structures; Terrabond serrated brass or aluminium strip for terrazzo work; and extruded sections for structural and decorative work. Strong but light wrought aluminium alloys have made possible far-reaching developments in vehicle and ship construction, and applications will be illustrated by two panels. Condenser tubes, with samples showing the various types of corrosion to which they are subject will also be displayed. Two panels will illustrate the work of the Division's Research Department, one dealing with progress in the production of wrought titanium, and the other with the various techniques employed in the welding of copper-base and aluminium-base alloys.

The MCKECHNIE BROTHERS stand (D.500) at this year's Fair has been completely redesigned. It will be larger than in former years, and the exhibits displayed thereon will indicate the ever-widening ramifications of this Company. Among the many examples of MKB products on view will be extruded rods and sections in brass, bronze, nickel silver and copper. Visitors will be impressed by the magnitude of the MKB output of high-speed screwing brass rods, brass and bronze stampings, chill cast bars, anti-friction metals and non-ferrous ingots. Another interesting display features sulphate of copper, electrolytic copper powder, copper cathodes and lithopone—all of which are produced at the Widnes Works of the Company in Lancashire. The range of MKB manufactures is completed with a display of "Spider Brand" and other solders which are produced at the MKB Works in Stratford, London.

THE BIRMINGHAM BATTERY & METAL CO., LTD., will have their usual striking display on Stand D.514.



Courtesy of H. & F. Precise Castings, Ltd.

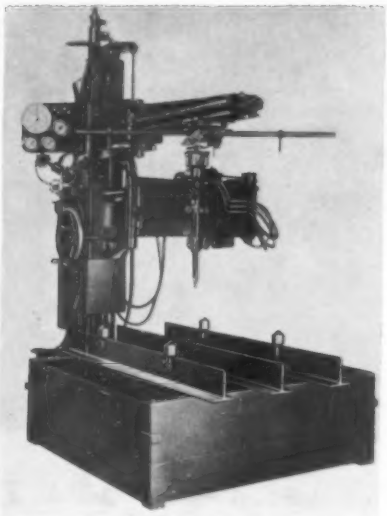
Selection of precision castings of a general engineering nature.

It will show a representative selection of the products of the Company, including tubes, plates, sheets, strip, rod and wire. The emphasis will be on the heavier products, the stand being dominated by pillars of very large diameter brass and copper tubes similar in size and finish to those produced for the paper and textile industries. One side of the stand will be screened by extra large and heavy plates, whilst well to the fore will be examples of sheet and strip, the special Dona copper being largely used for welded vessels and pipes: the Company has always been a major supplier of "tailor-made" rather than standard size products.

As usual, the emphasis of the display of THE DELTA METAL CO., LTD., on Stand D.311, will be mainly on extruded sections, of which an infinite variety will be on view, representative of the tens of thousands for which tools are available. The applications of some of these sections, which are available in brass or bronze, may be somewhat obscure, but cut into short lengths, drilled, tapped, etc., they form essential but often hidden components of domestic and commercial equipment. On the other hand, the purpose of many other extrusions will be readily recognisable—for example, the section of handrailing and other ornamental mouldings. High speed free cutting brass rod will be in evidence on the stand, together with the Delta Company's well known hot stamping rods. The exhibit will also include examples of welding rods and flux for gas welding, as well as hollow extruded bars, rolled strip and wire, and light extruded sections made by associated firms.

Wrought non-ferrous products will also be featured by BARKER & ALLEN, LTD., on Stand D.507, where the exhibits will include nickel-silver and cupro-nickel sheet, strip and wire in all qualities, together with brass, copper and bronze.

Specialists in the production of centrifugally and chill-cast bronzes, JOHN HOLROYD & CO., LTD. (D.210), will be displaying a range of finish machined bushes and gear blanks, centrifugally cast tubes, and chill-cast bar in Spuncast Holfos Bronze (centrifugally cast), Super Holfos Bronze (centrifugally cast), and Holfos Bronze



Courtesy of the British Oxygen Co., Ltd.

55 in. universal cutting machine

(chill cast). Other exhibits will include a number of standard worm reduction and other gear units.

A point of interest regarding Stand D.703/602, where the TOMEY GROUP will be exhibiting examples of their products is that the parent company, JOSEPH TOMEY & SONS, LTD., is this year celebrating its centenary. The metallurgical products of the group include non-ferrous castings and chill cast sticks, phosphor-bronze bushes, and aluminium and zinc-base die castings.

Reference has already been made in the previous section to the precision castings being shown by DELORO STELLITE, LTD., and H. & F. PRECISE CASTINGS, LTD., some of which are in non-ferrous alloys, but there are a number of stands on which the more common non-ferrous alloys will be shown in the form of castings. These include D.604, where CHARLES CARR, LTD. (incorporating THE NON-FERREOUS CASTING CO. (BIRMINGHAM), LTD.), will be showing castings in various bronzes; railway axle-box bearings, whitemetal lined and machined; chill cast phosphor-bronze rods and tubes; brazing solder; and non-spark tools. UNIVERSAL ENGINEERING CO., whose products include pressure and gravity die castings in aluminium- and zinc-base alloys and sand castings in aluminium alloys, copper-base alloys and other non-ferrous metals, will have a selection of them on show on Stand B.220. Non-ferrous castings and chill cast phosphor-bronze bars will be featured on Stand D.616/717 by C. & L. HILL, LTD., whilst KAYE ALLOY CASTINGS, LTD. (D.405/304), will be showing non-ferrous die castings.

In the light alloy field, ESSEX AERO, LTD., on Stand D.434, will be showing examples of castings, pressings and forgings in magnesium alloys.

No details are yet available concerning the exhibits of LANGLEY ALLOYS, LTD. (D404), N. M. ROTHSCHILD & SONS (D429), and THE YORKSHIRE COPPER WORKS, LTD. (B723/634).

Welding and Cutting

Three new items of equipment for welding and cutting metals will be shown by THE BRITISH OXYGEN CO., LTD., on Stand D.200/100. Argonaut welding is an automatic welding process using an inert gas shielded arc with a consumable electrode. It has great scope for all-position welding on heavy gauge light alloy plate, and it can also be used on stainless steel and copper-base alloys. The second new development on show will be the Argonarc spot welding equipment which is suitable for spot welding stainless and bright mild steels. Access to only one side of the joint is required, and material up to $\frac{1}{16}$ in. thick may be joined to any greater thickness or sections of any shape. Lastly, demonstrations will be given on the 55 in. universal cutting machine fitted with the new MC12 cutter using Cutogen one-piece nozzles. Both this and the 36 in. machine shown can be adapted for powder cutting of stainless steel. The display will be completed by a selection of cutting and welding blowpipes, Argonarc equipment, and ancillary equipment and welding materials.

The outstanding exhibit in the display of resistance welding machines on the stand of SCIAKY ELECTRIC WELDING MACHINES, LTD. (C.222), will be an improved type heavy duty projection welding machine—Type PAD400—of nominal 400 kVA rating. It is claimed that the improvements incorporated, together with a complete departure from conventional design, result in a machine with three times the efficiency of the conventional type. Secondary currents up to 120,000 amp. can be obtained across the tee slot platens, and a dual transformer arrangement ensures even welding current distribution over their whole 14 × 14 in. area. The top platen is actuated by a 12 in. diameter air cylinder developing up to 10,000 lb. ram pressure. The machine is fully automatic under push-button control. Other machines on show will include a Type SAC25/2 spot and stitch welding machine suitable for mild steel, 18-8 stainless steel and Nimonic; and a Type RAMU75 universal seam welding machine, also suitable for roller spot welding, which can handle the same materials.

New developments to be shown on Stand C.719/620 (HOLDEN & HUNT, LTD.) are single and two head heavy duty rivet heaters of 16 and 25 kW capacity. These machines are designed to suit the arduous conditions encountered when continuous heating of rivets of the



Courtesy of Sciaky Electric Welding Machines, Ltd.

Type PAD 400 heavy duty projection welding machine.

larger sizes is required. A range of C.S.A.-approved foot-operated spot welders specially designed for the Canadian market will also be shown. The vertical sliding adjustment to the bottom arms enables quick and accurate adjustment to be effected to suit differing welding set-ups. Butt welders for wire will also be exhibited on this stand.

In the arc welding field, a full range of electrodes and arc welding equipment will be displayed by INVICTA ELECTRODES, LTD. on the OWEN ORGANISATION stand, D.616/717.

The emphasis on the stand of SUFFOLK IRON FOUNDRY (1920), LTD. (D.620), will be mainly on the Sifbronze welding advisory service, giving technical information and advice to customers. The exhibits displayed will include oxy-acetylene welding rods, fluxes and equipment.

Rolls for Rolling Mills

The imposition of rigid specification for a rolled product in the ready-to-use and true-to-gauge condition, has necessitated rolls possessing the ideal surface structure, to suit a wide range of product, whilst the introduction of continuous rolling with the attendant changes in bearing design has led to radical revision of tolerance limits. The continued need for improvement has presented new and difficult problems to the roll maker. Such opposed characteristics as hardness and toughness, wear resistance and heat resistance, rigidity and flexibility, must be combined to give optimum results. A wide range of rolls will be exhibited by THE BRITISH ROLLMAKERS CORPORATION, LTD., on Stand D.517, together with large charts illustrating the range of cast steel and cast iron rolls produced and their uses for hot and cold rolling.

Closeloy rolls have achieved a reputation as being representative of the best rollmaking practice, and a very wide range of these rolls is produced. Those shown on Stand D.235/136 by SIR W. G. ARMSTRONG WHITWORTH & CO. (IRONFOUNDERS), LTD., will include a pair of chilled iron rolls and a rather interesting exhibit in the form of a Closeloy P.M. roll mounted vertically and showing three distinct stages in its manufacture. The first section of this roll will be as cast, another as rough machined, and a third as finished. This roll will be a finishing roll for the top position in a three-high mill rolling 5 in. × 3 in. joists.

Foundry Equipment

One of the most important developments in the foundry industry in recent years has been the introduction of the shell moulding process, in which castings are poured into moulds consisting of thin "shells" or "biscuits," made by investing a hot metal pattern plate with a mixture of sand and a phenolic resin and baking in an oven. One of the main advantages of the process is the excellent surface finish obtained on the casting, but it has other points in its favour. The manual effort involved is very small and it is possible to reduce this still further by the use of specially designed moulding machines. Labour for core making and coring-up can also be reduced in many instances because the increased strength of shell moulds allows the use of built-in cores. The process will be demonstrated by the POLYGRAM CASTING CO., LTD., on Stand C.306, where the Polygram automatic shell moulding machine Mark V, with fully automatic rollover of the investment bin and pattern



Courtesy of Holden & Hunt, Ltd.

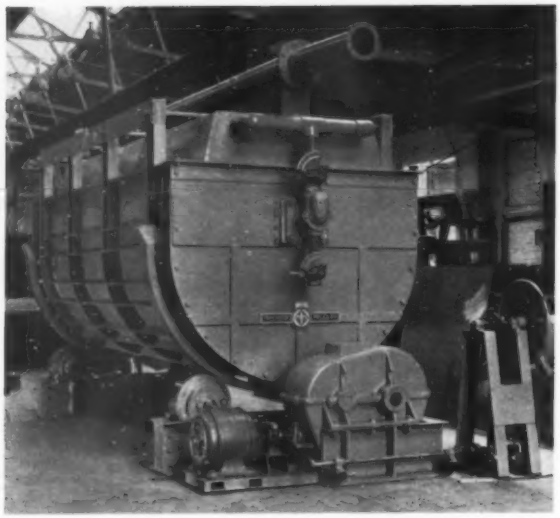
10 kVA rocker arm type air-operated welder

plate will be seen in operation. This machine turns out two half moulds a minute and souvenir castings will be made from them on the stand, so that engineers can examine them at their leisure. Numerous castings will also be on show, and details will be available of the Polygram licensing system.

Automatic shell moulding will also be demonstrated by FOUNDRY EQUIPMENT, LTD., who will have on show on Stand D.301/200, an F.E. (Sutter) machine, Foundry Equipment having been appointed sole licensees for the manufacture and distribution of all machines formerly made and sold only by Sutter Products Co., Dearborn, Michigan, the products being styled F.E. (Sutter) machines. Other foundry plant to be demonstrated on this stand includes an R.S.M.3 resin sand mixer; a "Junior" automatic electric sandrammer; a B.1 hydraulic boxless high-speed moulding machine, with independent oil hydro-electric unit; an F.E.2 hydraulic under-sand frame moulding machine, with independent oil hydro-electric pump unit; and a complete semi-mechanised sand conditioning and distribution plant, incorporating a B.M.2 batch-type sand mill.

On Stand D.117, THE FULLERS' EARTH UNION, LTD., will be showing, among their other exhibits, Fulbond for bonding foundry moulding sands. The use of Fulbond with silica and natural sands will be demonstrated on test apparatus, and a number of castings and cores will be shown to which Fulbond has been added to give them green strength.

In addition to a display of Salamander, and Salamander "Super" crucibles on the stand of the MORGAN CRUCIBLE CO., LTD., (D.305/204) there will be shown the new Salamander "Suprex" crucibles, designed for operation under specially arduous conditions. The plumbago accessories will include a range of launders, muffles, knock-off riser plates, moulds, stoppers and nozzles, tundishes, stirrers, skimmers, and bricks and shapes for steel ladles and other linings. Three recent developments which are likely to arouse much interest are: one-piece Salamander plumbago crucible linings for use in conjunction with stamped steel shells;



Courtesy of Monometer Manufacturing Co., Ltd.

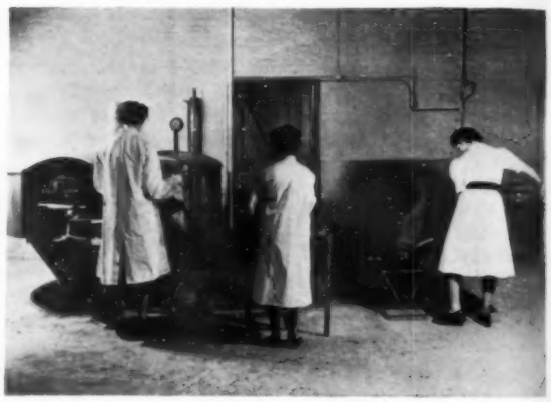
Fully mechanised oil- or gas-fired hot metal receiver.

Salamander plumbago tubes for degassing metals; and Morganite pyrometer tip tubes. A recent development of an associated company which will be on view is the ceramic strainer core, whose effectiveness has been proved by field tests. Space will not permit the exhibition of any of the larger crucible furnaces, but members of the staff will be available to discuss problems related to them.

Equipment for melting metal and for handling it in the molten state will be shown on Stand D.731 by MONOMETER MANUFACTURING CO., LTD. On the melting side there will be large and small Monometer fully mechanised oil-fired rotary furnaces for both ferrous and non-ferrous alloys. Such furnaces are used for the bulk melting of metals for die casting foundries, ingot makers, and iron and steel foundries. There will also be exhibited a Monometer fully mechanised oil-fired hot metal receiver for holding iron tapped from the cupola ready for the intermittent feeding of ladles, and for supplying molten iron to continuous casting boxes on the conveyor system. For feeding holding furnaces, a Wellworthy patent hydraulic truck ladle will be on view.

The Lester HHP–ICC die casting machine for aluminium, brass and magnesium to be shown by DOWDING & DOLL, LTD., on Stand D.211/112, is a new self-contained model equipped with the Lester cold chamber injection system. It has a one-piece cast steel beam-type frame, conservatively rated at 130 tons locking pressure, and die platens of large area are unobstructed.

BAKELITE, LTD., has done pioneering work on the shell moulding process, which is, of course, based on synthetic resins, and is now mass-producing several different grades of resin for this purpose, and for recent developments, one of these being the bonding together of half moulds instead of using clips. An array of moulds and cores produced by the shell process will be displayed on Stand C.404.

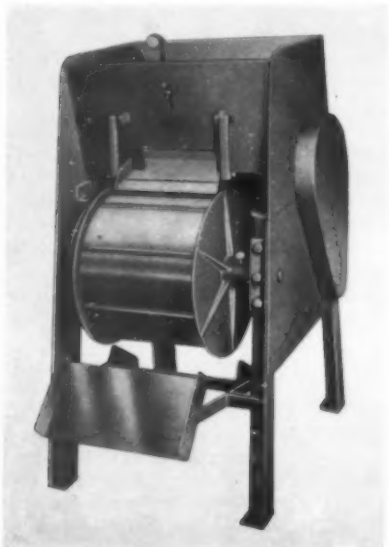


Courtesy of Polygram Castings, Ltd.

Mark V automatic shell moulding machine in operation.

A comprehensive range of exhibits to be shown by ELECTROMAGNETS, LTD., on Stand C.605, includes a lifting magnet, a swarf separator, a high intensity chute type separator, and various types of permanent magnet separators. An item of particular interest will be a high intensity overband type of magnetic separator which can be used for removal of tramp iron from foundry sand, etc. It gives a continuous discharge of all collected iron, and is easy to instal over existing conveyors. Also on show will be a Boxmag high intensity conveyor head unit, which gives some three times the separating power of a magnetic pulley or drum of comparable size, built into a shortband conveyor.

Both permanent magnet and electromagnetic separators will be seen on the stand of RAPID MAGNETIC MACHINES, LTD. (C.421), and a new portable foundry separator for the removal of ferrous material from foundry sand will be demonstrated. There will also be a new patent flux-controlled chute which utilises Alcomax permanent magnets and can be de-energised for the removal of accumulated tramp iron. Two permanent magnet separators for treating swarf, scrap, etc., will be shown in operation, as will the Magnalift, the Company's newest addition to its wide range of electromagnets for lifting.



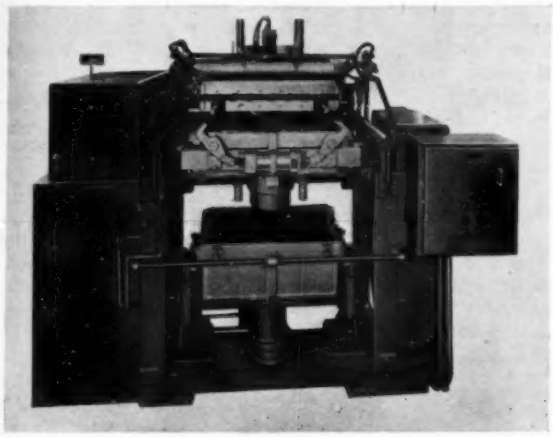
Courtesy of Rapid Magnetic Machines, Ltd

Magnetic separator with jig shaker feed tray

In association with its two subsidiaries, STANDARD BRICK & SAND CO., LTD., and JOSEPH BOAM, LTD., BRITISH INDUSTRIAL SAND, LTD., will be showing on Stand D.119 a full range of sands from their Redhill and Kings Lynn quarries. Of particular interest to the foundry trade will be a display of sands produced specifically for shellmoulding, together with castings made by this process using Redhill sand.

Tubes and Pipes

The use of ever increasing steam temperatures in power station generating plant has necessitated the development of steels which will withstand the stress, temperature and atmospheric conditions prevailing in the steam-raising and steam-using units, and in the connecting pipework. AITON & CO., LTD., who specialise in this class of work, will have on show, on Stand D.608, a steam pipe in austenitic steel for the new British Electricity Authority Power Station at Drakelow. This is designed for normal operating conditions of 1,500 lb./sq. in. gauge and 1,060° F. total temperature. Several new problems have had to be met in dealing with operating conditions of this order and more than ordinary care has to be taken in the fabrication of the pipes. A further exhibit will be a section of a steam receiver showing the anti-corrosion fatigue device which has been fitted to all receivers for some time now. There will also be displayed examples of steel and cast iron pipework, steel pipe joints, various types of expansion pieces and a model of the P. & B. evaporator distiller.



Courtesy of Foundry Equipment, Ltd.

S.P. 1000 shell moulding machine (stripping cycle).

The main feature on the stand of SERCK TUBES, LTD. (D.618), will be a slowly revolving centre table displaying tubes in copper and its alloys from 2½ in. diameter down to approximately $\frac{1}{16}$ in. diameter in heavy and light gauges. The exhibit will show solid drawn tubing in both round and shaped sections, with each group labelled and identified with its particular trade. The stand will be shared by the associated Company, SERCK RADIATORS, LTD., who will have on show a range of heat exchanger units in which they specialise.

No details are to hand at the time of going to press concerning the exhibits of the YORKSHIRE COPPER WORKS, LTD., but, no doubt, a wide range of non-ferrous tubing, in which the Company specialises, will be displayed on Stand B.723/634.

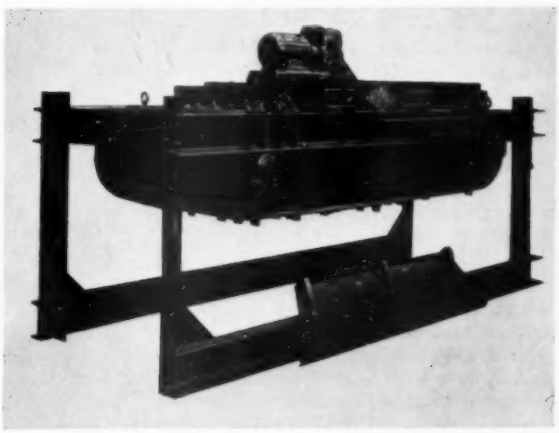


Courtesy of W. Canning & Co., Ltd.

"Lacomatic" No. 2 centrifugal lacquering machine.

Wire

The LONDON ELECTRIC WIRE CO. & SMITHS, LTD., together with associated companies, FREDERICK SMITH & CO., THE LIVERPOOL ELECTRIC CABLE CO., LTD., and VACTITE WIRE CO., LTD., will display bare and insulated conductors for all electrical purposes on Stand C.717. These will include the well-known Lewcos products—cotton, silk, paper, enamel, Lewmex, Lewmexglas and Lewbestos insulated wires and strips; copper braids and cords; covered resistance wires and Glazite connecting wires; Anacos bare copper and copper alloy wires, strips, strand, sections and forgings; power transmission line wires, trolley wires and telegraph and telephone line wires; aerial wire and earth rods; L.E.C. rubber, paper and cambric insulated cables for use in mines, quarries, ships, factories, railways, etc.; underground power cables and domestic flexibles. Eureka and Vacrom resistance wires and tapes, molybdenum rods, wires and tapes, and special wires for the electric lamp,



Courtesy of Electromagnets, Ltd.

High intensity overband type of magnetic separator.



Courtesy of Electrochemical Engineering Co., Ltd.

Efco-Udylite Junior fully automatic plating plant being loaded for despatch to Sweden.

radio valve and cathode ray tube industries will also be on view.

This year, JOHN RIGBY & SONS, LTD., have altered the general design of their stand, D.607, in that there will not be such a large volume of steel wire on show, although a completely representative range will be displayed. This year they will again be making a special feature of their precision drawn pinion rod in steel, brass and nickel silver for use in the manufacture of toys, meters, clocks, etc. Reference is made elsewhere to their powder metallurgy products.

One of the new products to be displayed on the stand of BRITISH ROPES, LTD. (D.349/244), will be a braided wire rope sling, which consists of eight steel wire ropes braided together. These slings are extremely flexible and resistant to kinking, and there is very little tendency to twist or spin. A full grip can be taken on the load thus preventing slippage and damage to the load. Successful uses include lifting heavy rolls in rolling mills, electrical equipment, awkwardly-shaped machines, and equipment with highly-machined surfaces which might be damaged by other methods.

The emphasis in the steel ropes section of Stand D.411 (WRIGHTS' ROPES, LTD.), will be on the diverse types available to-day. The exhibits in this section will include winding ropes, locked-coil aerial ropes and ropes made for special purposes, whilst in the fibre rope section metallurgical interest will centre chiefly on the drop stamp ropes. On the same stand, THE ROLLASON WIRE CO., LTD., will have on show a selection from their comprehensive range of alloy and high strain steel wires.

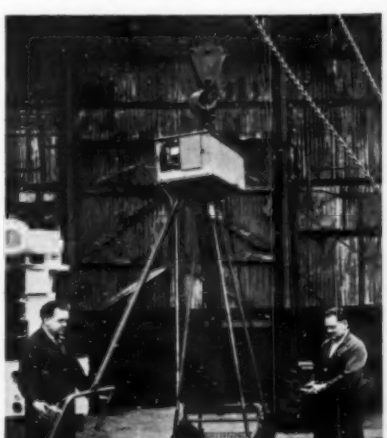
Other firms displaying wire and wire products will include LEE OF SHEFFIELD, LTD. (D.530), who will be showing high-grade steel wire and stainless steel wire; PADLEY & VENABLES, LTD. (D.525/422), stainless steel wire; RICHARD JOHNSON & NEPHEW, LTD. (B.417/322). ferrous and non-ferrous wires; RYLANDS BROS., LTD, (C.319/228), bright, annealed, coppered, galvanized and tinned steel wires, fencing, nails and various wire products; and THE WHITECROSS CO., LTD. (D.621), whose display will include similar items together with copper wire, welding wire, rolled steel strip, nails, fencing, and ropes for mining, shipping and engineering purposes.

Electroplating

Some indication of the many applications of Fescolising will be given on Stand D.529, where FESCOL, LTD., show its value in renewing worn parts and prolonging the working life of new components. The exhibits will show the variety in treatment available, ranging from light protective coatings of nickel through heavy ground deposits of nickel, to light and heavy deposits of chromium. An interesting new application of the process will be illustrated by a 5 ft. 3 in. long roll for the photographic industry. Made in light alloy, a heavy ground deposit of chromium has been applied direct on the basis metal. Of special metallurgical interest will be the various Fescolised rolls, and the contrast between a Fescolised and an untreated hydraulic ram.

The outstanding exhibits on the CANNING stands (D.207/108 and D.209/110) will be two model plating plants. One, originally constructed in 1927, represents a large number of plants made between 1924 and 1939, whilst the other is an ultra modern version of a hydraulically operated power driven unit. Other exhibits will include a number of filter units—a 1,000 gallon plate-type unit, a Rotunda unit, a Corona unit for use with alkaline solutions, and a Tynee unit for small installations. A typical control unit for an automatic plating plant will be on view, whilst plating barrels will be represented by a submerged Quickplate type unit, and the Models 1–2 Duomax barrels. Designed for lacquering small parts in bulk, the Nos. 1 and 2 Lacomatic centrifugal lacquering machines will be exhibited, whilst other finishing equipment will include a 20 in. diameter 8-spindle automatic polishing machine, a centreless polishing machine, and a Gallay rotary finishing barrel. There will also be a selection of resistance boards, and a comprehensive range of plating salts, mops, brushes and polishing compositions.

On Stand C.611, the ELECTROCHEMICAL ENGINEERING CO., LTD., will be showing an Efco-Udylite fully automatic Junior plating machine operating mechanically. This is a low-priced return-type automatic of standard construction, with an output of 100 racks (200 sq. ft.) per hour. A wide range of process sequences can be incorporated and a hot air dryer is included. Normally, the Junior is used for bright nickel, chromium, zinc,



Courtesy of Thompson Bros., Ltd.

Spelter bath drossing machine.

cadmium or brass plating, or for various non-electrolytic processes. Also on show will be the latest designs of Efco-Udylite fully immersed plating barrels, and samples plated by Efco-Udylite processes.

The exhibits of R. CRUIKSHANK, LTD., on Stand D.226, will include a cross-section of the types of plating and polishing plant made by the Company, together with the complete range of polishing mops, compositions brushes, etc. A new item on show will be a multi-oblique plating barrel with four baskets, each with individual drive. Also displayed will be new modifications to the Cruikshank centrifuges; a Senior plating barrel fitted with provision for two speeds; a burnishing barrel; a Junior plating barrel; and a complete P.R. copper plating and filtration unit, together with samples.

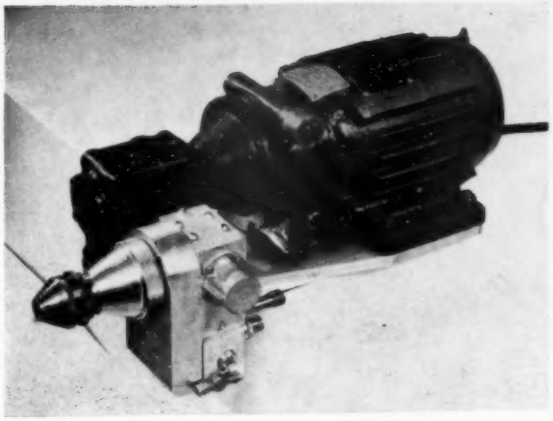
A full range of stitched and unstitched polishing mops will be shown on Stand D.700, by JOHN HAWLEY & CO. (WALSALL), LTD., along with many types of brushes, polishing compounds and accessories. Of particular interest will be the Aircool bias wheels and a unique development of them, an impregnated buff which is claimed to save by 50% the amount of polishing composition used. A recently developed liquid buffing compound which will also be featured on the stand, is claimed to have many advantages over the old bar compo.

For the lining of tanks containing chemicals, CARBLOX, LTD., an associate Company of THE MORGAN CRUCIBLE CO., LTD., will be showing on Stand D.305/204 a wide range of bricks and tiles which combine high chemical inertness with excellent abrasion resistance, whilst J. H. SANKEY & SON, LTD., will display on Stand B.405 their vitrified acid and alkali-resisting tiles and bricks.

Pumps and valves for handling plating solutions and other corrosive liquids will be featured on the stands of MONO PUMPS, LTD. (D.716), MERRILL PUMPS, LTD. (D.747), and WYNN (PRODUCTS), LTD. (D.747), further details being given under the heading of "Miscellaneous."

Other Surface Treatments

The use of metal spraying for building up worn parts and for the recovery of parts that have machining errors is now standard practice. Among the exhibits of metal spraying equipment on Stand Outdoor 1348, METALLISATION, LTD., will be showing their latest tool post motorised spraying pistol. This, the Mark 30, is an improved version of the Mark 27, and although the rate of deposition has been increased considerably, the quality of the coating has been retained. The infinitely variable gear gives finger tip control and the change from one gauge of wire to another, and from one type of metal to another, can be carried out with the minimum of adjustment to the tool.



Courtesy of Metallisation, Ltd.

Mark 30 motorised metal spraying pistol designed for toolpost operation.

A film entitled "Hardfacing by the Oxy-Acetylene Process," showing the correct way to prepare blanks and deposit Stellite will be shown at regular intervals on Stand D.402 (DELORO STELLITE, LTD.). The stand itself will exhibit many applications of Stellite in industry, and there will be a complete hardfacing bench in operation. Experts will be available throughout the Fair to discuss hardfacing problems.

Examples of architectural ironwork, rust-proofed by the sherardizing process (coating with zinc by heating in zinc powder) will be displayed on Stand B.724 by the ZINC ALLOY RUST-PROOFING CO., LTD. The Company does not manufacture architectural ironwork but specialises in carrying out sherardizing for the makers of casements, metal trim, screws, nails, etc.

Originally designed for rapidly emptying hot fluid spelter from a galvanizing bath, the T.B. vertical pump to be shown by THOMPSON BROTHERS (BILSTON), LTD., on Stand D.637 has wider applications and is serviceable where low-melting point metals have to be handled in bulk. Another Thompson exhibit, namely the direct drive centrifugal machine, has applications in the galvanizing field where it is used for the removal of surplus zinc from hot-dipped parts. An essential feature of the machine is the minimum of time lag between withdrawal of the basket from the coating bath and spinning. Completing the galvanizing exhibits will be a drossing machine, which consists of a mechanically operated perforated grab, for the quick and easy removal of dross from the galvanizing bath.

The Rust-Anode process to be featured by C. & P. DEVELOPMENT, CO. (LONDON), LTD., on Stand B.201, has been referred to as cold galvanizing. One of the most recently developed media for protecting iron and steel from



Courtesy of Roto-Finish, Ltd.

Flushing out the DW22-36-1 machine.



Courtesy of Alfred Bullows & Sons, Ltd.

PR303E portable spray plant incorporating Hydrovane compressor.

corrosion is a paint containing zinc. The degree of protection afforded by such a paint increases with the pure zinc content of the coating, which in the case of Rust-Anode is 95%. The pure zinc film ensures that metallic contact is maintained throughout the coating, and between the coating and the base metal, thus ensuring cathodic protection.

A new version of the Company's paint stripper, to be shown by JENOLITE, LTD., on Stand B.221, is considerably more effective than the old one. Applied with a brush, it softens the paint which may be speedily removed with a rag. Other exhibits will include Jenolite Rust Remover and Neutraliser, and Jenolite Chemical Sealer, which is an alternative to red lead and other primers, and is most effective for use with the rust remover.

Processes for finishing, colouring and protecting metal components will be featured by METAL PROCESSES, LTD., on Stand D.229. Since the last B.I.F. two new black finishes, Turbla and Brunette have been developed. Their application is the same as Mark II Black, but they are appreciably cheaper. For the aircraft industry, the new Degresol aluminium degreaser will be of special interest.

ROTO-FINISH, LTD., will be showing for the first time on Stand D.235/136 their medium-sized D.W.22–36–1 machine for precision barrel finishing. This machine is designed for the full range of Roto-Finish processes, from precision de-burring, uniform radiusing, descaling—leaving a bright polish—to the final high quality polishing and honing. Of particular interest will be a standard Roto-Finish barrel, one side of which is completely faced with toughened glass.

On the FOLLSAIN-WYCLIFFE stand (D.709) will be exhibited examples of carburising boxes, etc., made in mild steel and Penetral treated to render them resistant to oxidation at temperatures up to 1,000° C.

The main exhibit on Stand D.743/642 (ALFRED BULLOWS & SONS, LTD.) will be the range of Bullows Hydrovane rotary compressors which possess a number of interesting features. A 10-ft. wide water wash booth will be shown as a working exhibit with an automatic traversing spray gun and fitted with a Bullows mechanical scummer.

A special feature of Stand A.622, which THE MIDLAND FAN CO., LTD., is sharing with its associate, B.I.F. ENGINEERING CO. (1940), LTD., will be a spray booth designed exclusively for the vitreous enamelling industry. The remaining exhibits will include sheet metal work, fans, spray booths, spray pistols and compressor sets.

Surface hardening equipment and exhibits will be featured by FLAME HARDENERS, LTD. on stand D.131.

Furnaces and Refractories

As last year, the exhibits of the INCANDESCENT GROUP on Stand C.727/628 will take the form of scale models of typical installations. There have been a number of changes in the particular models on show, and on this occasion THE INCANDESCENT HEAT CO., LTD., will be represented by: (1) a producer gas-fired balanced hearth walking beam furnace; (2) a gas-fired radiant tube refractory roller hearth furnace; (3) a complete heat-treatment installation, including recuperative furnaces, mechanised quench tanks, etc. (working model); (4) Incandescent Whiting twin cupola installation with swivel charging mechanism, the plant being arranged for continuous pouring; (5) an oil-fired bogie hearth furnace, with Incandescent-Laclede suspended arch construction, for the treatment of mill rolls; and (6) a Hi-Nitrogen generator. A continuous drum spraying and drying plant will represent CONTROLLED HEAT & AIR, LTD., and a three-phase swing-roof tilting arc furnace for steel melting METALECTRIC FURNACES, LTD. The products of SELAS GAS & ENGINEERING CO., LTD. (not models) will form a display of gas and oil burners, mixing apparatus, and bench-type muffle furnaces, whilst METAL PORCELAINS, LTD., will be exhibiting finished vitreous enamelled samples. THOMPSON L'HOSPIED & CO., LTD., is the member of the Group supplying heat-resisting alloy castings for internal use and outside sales. A live working exhibit will be shown on the Gas Council stand—a continuous bright brazing furnace with radiant tube heating.

On the ALFRED HERBERT Stand (D.321) there will be a No. 8 Atritor Dryer-Pulveriser on view together with photographs of typical installations. In this unit, which was primarily developed to pulverise coal for firing boilers, cement kilns, metallurgical furnaces, etc., drying is particularly efficient, a moisture content of 25% being reduced to less than 1% in one pass.

Included in the special heat-resisting steel castings on Stand D.225/126 (DARWINS, LTD.) will be perrets, boxes, salt pots, etc., whilst FOLLSAIN-WYCLIFFE FOUNDRIES, LTD., on Stand D.709, will be exhibiting carburising boxes, pyrometer sheaths, cyanide pots and other furnace parts in E.V. heat resisting steel, in Wynite heat resisting cast iron, or in Penetral-treated mild steel.

On the refractories side, the display of JOHN G. STEIN & CO., LTD., on Stand D.313, will consist essentially of samples of bricks from their extensive range. This will include silica bricks for open-hearth purposes, both of normal quality and super duty; fire bricks ranging in alumina content from 32–42%; high alumina bricks containing 50–73% alumina, and including special bricks such as Stein Mullite (72% alumina), and Stein Sillimanite (60% alumina); and basic refractories, including straight magnesite, chrome magnesite and chrome. Also on show will be samples of refractory cements and of ramming and casting refractories.

The refractories section of Stand D.305/204 (THE MORGAN CRUCIBLE CO., LTD.) will show the wide

diversity of shapes and materials available. The central features of the display will be devoted to the two new refractories recently introduced. The M.R.1. super-duty firebrick has been developed to give longer life in positions where normal firebrick is liable to fail rapidly by such factors as excessive temperature, slag attack and thermal spalling. The other development, a low storage insulating refractory M.I.28, can be used up to 2,800° F. (1,538° C.), either as a backing insulation or for the complete furnace lining itself in cases where conditions of slagging or abrasion are not severe. Attention will also be drawn to M.R. Plastic Mouldable, whose main characteristics are a high degree of refractoriness, volume stability under high temperature and loading, and freedom from spalling. The most recent addition to the Morgan range, Centurion combustion tubes are suitable for use at temperatures up to 1,500° C., and are impervious to gases at the usual temperatures. The range of refractory bricks will include a selection of grades for use in heat-treatment furnaces, boiler settings, oil stills, steel ladles, etc., made by Morgan's associates, THE DOUGLAS FIREBRICK CO., LTD. Attention will also be directed to Triangle laboratory ware, pyrometer sheaths, electric furnace crucibles, and pure oxide ware. Of special interest will be the display of Carblox corrugated hearth blocks and standard shapes for blast furnaces.

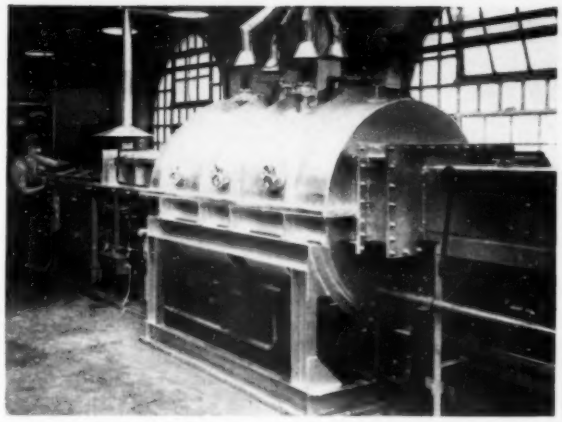
The usual range of heavy refractories made from P.B. Sillimanite will be shown on Stand C.622 by THE P.B. SILLIMANITE CO., LTD. These include furnace bricks, kiln equipment, glass-tank blocks, and ramming mixtures for the formation of monolithic linings for melting furnaces. In addition there will be laboratory ware in the form of crucibles, pyrometer tubes, combustion tubes and accessories, refractory cements, and special Sillimanite grains from which refractory concrete is made. The use of ethyl-silicate bonded refractories will be demonstrated, as well as the extent to which the special application of this method has multiplied. Finally, there will be a range of samples of Sillimanite grains for the many purposes for which the material is used.

CELLACTITE AND BRITISH URALITE, LTD. (B.313/212), will include amongst their exhibits Kimolo insulating bricks and hollow partition blocks, made from Moler earth whose minute cellular structure assures the highest degree of heat insulation. Other exhibits on this stand will include Cellactite permanent steel-cored corrugated



Courtesy of Ether, Ltd.

Type PC 10/E potentiometer indicator.



Courtesy of The Incandescent Heat Co., Ltd.

Gas-fired continuous bright brazing furnace with radiant tube heating.

sheeting and ventilators; Urastone asbestos cement for flue pipes, etc.; Kimoloboard workable, non-combustible panelling board; and Asbestone asbestos cement sheeting.

On the stand of J. H. SANKEY & CO., LTD. (B.405), Pyruma, Siluma and Aluma fire cement will be displayed along with Sankey's super acid-resisting cement and various types of acid-resisting bricks and fire-bricks. The latter will include Andaluma, a new firebrick containing 51% alumina.

A range of plastic and powder refractory cements will also be shown by PURIMACHOS, LTD., on Stand D.251. These will include Purimachos, a plastic fire cement made in a number of grades; and Drykos and Alukos, powder fire cements for use where specially high temperatures are encountered.

Temperature Measurement and Control

Stand C.700 (ETHER, LTD.), will house a full range of temperature recorders, controllers and indicators, mostly based on electronic principles. The Widestrip potentiometer (Type WSP/E), gives six records on a 10 in. wide chart. This instrument is capable of writing speeds up to 3½ seconds, without overshoot, with chart speeds of up to 360 in. per hour. It is also made as a recording automatic controller using high-low, multi-stage and proportional processes. The Ether potentiometer indicator (Type PC 10/E) has a 30 in. scale and deflects from zero to full scale in 12 seconds. Fitted with a multi-point switch, it can indicate the temperature of up to 36 points automatically. It is also made as a high-low, multi-stage and proportional controller. Other exhibits will include a selection of Ether-Wheelco instruments; solenoid operated valves; radiation and optical pyrometers; surface pyrometers; and molten metal pyrometers.

A new development of INDUSTRIAL PYROMETER CO., LTD., will be shown on Stand C.716. It is a controlling pyrometer, to be known as the Pyrstat, which has several new and interesting features. There will also be exhibited a full range of instruments, comprising edgewise indicators, rotary switches, rotary-switch indicators, foundry indicators, portable indicators, indicating controllers, single and multi-point recorders and recording controllers, magnetic and motorised control valves, water column gauges and pressure switches.



Courtesy of Greenwood & Batley, Ltd.

Cold forging machine

THE RHEOSTATIC CO., LTD., will be demonstrating a wide range of temperature control equipment on Stand C.500, particularly in connection with central heating installations. The exhibits will include Satchwell thermostats for the control of rooms, ducts, ovens and liquids; flame failure devices; motorised valves; and controls for oil burners and automatic stokers.

Included in the display of wires and cables on Stand C.720 (PYROTENAX, LTD.), will be found examples of thermo-electric cables.

Machine Tools

Although that section of the machine tool trade concerned with cutting operations will not be represented at the Fair, there will be exhibits of interest to those engaged in the cold working of metals and alloys. A number of wire-drawing machines will be shown by SIR JAMES FARMER NORTON & CO., LTD., on Stand D.167, each embodying improvements introduced during the past year. Many of these machines will be in operation, and new features giving slow starting and gradual acceleration will be shown: the whole process from wire-drawing to finished cable will be demonstrated. A 10 ft. scale model of a high speed automatic tube drawbench will illustrate the principles introduced into the new design, whilst absence of noise in the operation of the rotary swaging machine will be demonstrated in swaging rods and tubes. Large machines, such as rolling mills, which cannot be exhibited because of their size, will be shown by means of a film. On the same stand, the associated Companies ANGLARDIA, LTD., and WIRE DRAWING DIES (MANCHESTER), LTD., will display diamond dies and tungsten carbide die pellets, dies, mandrels, plugs and small tools.

Many of the products of TURNER BROTHERS (BIRMINGHAM), LTD., such as press tools, jigs and fixtures are made to individual requirements so that they are not available for exhibition, but they will be represented on Stand D.512 by a display of pressings, mouldings and die castings made by them. The Company also manufactures power presses ranging from 6 to 70 tons capacity and has recently developed a tangent bending machine for use in the streamlining of such products as refrigerator cabinets. Some examples of the power presses will be on view, together with the Turner Brothers' saw tooth notching machine.

From the range of Oilaulic presses made by JOHN MILLS & CO. (LLANIDLOES), LTD., five have been selected for showing on Stand D.337. They are the 6-ton bench press, which has been re-designed to give faster working speeds; the 8-ton standard vertical bench press with straightening equipment; the 10-ton broaching press which has been used for broaching operations on gas turbine blades; the 15-ton forcing press, suitable for a variety of assembly operations, such as fitting gears and pulleys to shafts; and the 30-ton standard vertical press, supplied with or without straightening equipment. It is hoped to have on show two machines recently developed for manufacturing pit props from salvaged steel arches and joists. The gussetting and folding over operations are performed, respectively, on a 45-ton vertical press and a 30-ton horizontal press. Another coal industry application, which will be shown pictorially, is the 10-ton tub straightening and rectifying equipment.

The open-throat press for forming, straightening, arboring, stamping or forging, to be shown by FINNEY PRESSES, LTD., on Stand D.243, is one of a series of four ranging from 15 to 100 tons capacity. They are completely self-contained units incorporating Finney hydraulic equipment, which includes a hydro-pneumatic accumulator. There will also be a display of hydraulic pumps, valves, etc., which will include the Greer-Mercier hydro-pneumatic accumulator, manufactured under licence by Finney Presses, Ltd.

HORDERN, MASON & EDWARDS, LTD., will be exhibiting nine power presses on Stand D.603/502. Seven of these presses will be of the open-front type, ranging in capacity from 12 to 100 tons. Two of them will be fitted with automatic feeds; they are a 20-ton machine with a rotary table for feeding components to the slide, and a 40-ton press with strip and coil double roll feed mechanism. Double sided presses will be represented by the sturdy double-crank variable stroke model D.C.P.5, which is extensively used in the automobile, aircraft and allied industries, and by a toggle action drawing press incorporating a highly efficient worm drive which enables it to be compactly yet powerfully constructed. All the machines exhibited will be under power and in actual production of various components.

This year, COWLISHAW, WALKER & CO., LTD. (D.737/636), are showing two representatives of their range of single-acting crank presses. One is the type O.T.60 open-fronted multi-purpose press having a rated capacity of 75 tons. It has an adjustable bed which can be swung out of the way and special knee beds bolted on. It can also be made as a horning press, and an adjustable stroke device of 1 in. to 5 in. may be supplied on request. The other, a type E.C. double-sided single-crank press having a rated capacity of 200 tons, is one of a range which are essentially deep drawing models. All models are provided with the C.W. patent electro-pneumatic clutch-brake unit, and the type E.C. has compressed-air slide balance and motorised slide adjustment. It may also be provided with an adjustable stroke device of 1 in. to 6 in.

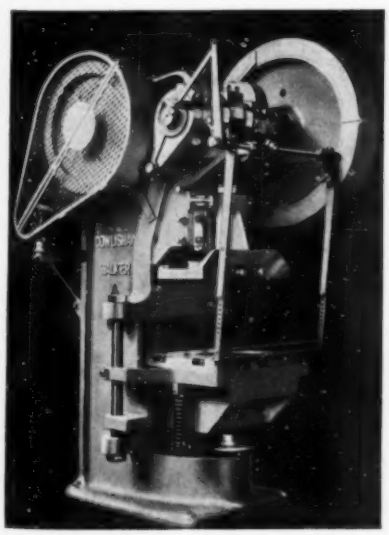
The 7½-ton Hare hydraulic power press to be shown by DOWDING & DOLL, LTD., on Stand D.211/112 is of compact design and rigid construction, being fabricated from heavy steel plate. The cylinder head, ram and valve blocks are machined from steel billets, and sensitive easy control is by hand or foot lever.

Certain new items of their British-built U.S. Tool Co. press shop equipment will be shown by ROCKWELL MACHINE TOOL CO. LTD. on Stand D.224. These will include the latest development of an independent slide feed specially designed for long pitches up to 24 in. and multiples of any pitch of 24 in. × 6 in. width. Contrary to normal feeds this type operates the press when the required length of material is fed. An additional new item will be the multi-stop device which incorporates a solenoid mounted to the clutch rod, limit switches being placed on the ingoing side of the feed to check the end of the coil, and between the feed and the tool to ensure that no buckled or otherwise damaged material is fed into the tool. For straightening very wide material prior to its operational stage a Model PDS 18 power driven stock straightener will be shown. Other items will include a coil cradle and a complete automatic press set-up with stock reel, stock oiler and wiper, stock straightener, slide feed, press and scrap cutter.

An improved type of interlocking press guard will be shown on several different presses on Stand D.601 (PRESS GUARDS LTD.). Although the method used to control the operation of the press will vary in all cases the principle of sequential operation will be incorporated in conjunction with new recommendations about to be published by H.M. Factory Department. An intensified brake will be fitted to one press in conjunction with the interlocking guard and will allow the guard to open half stroke on the press. In the event of an uncovenanted stroke occurring, the arrestor brake is designed to stop the press under power and cut out the motor.

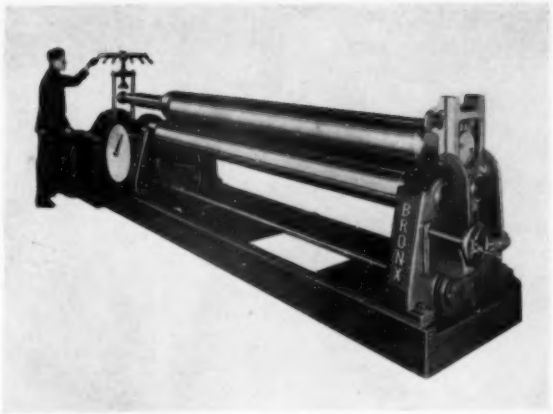
Fastrip press guards with arrestor mechanism will be shown by J. P. UDAL on Stand D.630. This type of guard is worked by compressed air and the guard and clutch are synchronised to ensure split-second timing. The arrestor mechanism fitted to the presses to be shown enables the Fastrip guard to be opened early during the upstroke of the press slide thus giving higher production rates with a higher safety factor than the standard type of interlock guard.

On Stand D.149 T. & J. BRETTELL LTD. will include in their exhibits a Carter patent hydraulic die cushion fitted to a power press in action. It is much smaller than a pneumatic cushion and no external power or compressor



Courtesy of Coulishaw Walker, & Co. Ltd.

75-ton multi-purpose press.



Courtesy of Bronx Engineering Co., Ltd.

Three-roll pyramid plate bending machine.

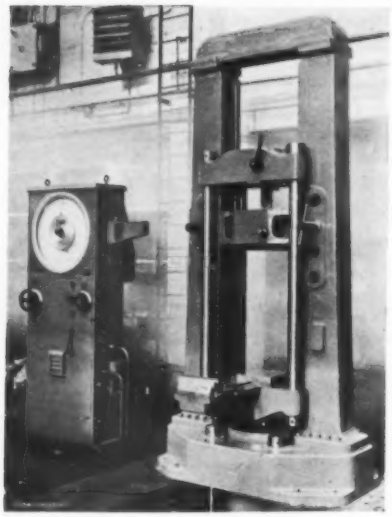
plant is required. Other press accessories will be featured by REDMAN TOOLS & PRODUCTS LTD. who will have on show a comprehensive range of units comprising the Redman Unipierce and Unicrop system of tooling for mounting on all types of presses and press brakes; and by G. P. A. TOOLS & GAUGES LTD. whose display of jigs and fixtures and press tools for blanking, piercing, forming and bending, will also be accommodated on THE GAUGE & TOOLMAKERS' ASSOCIATION stand, C.319.

A screw making plant to be shown in operation on Stand D.218 (GREENWOOD & BATLEY, LTD.) will comprise cold forging, bolt head trimming and thread rolling machines. The cold forging machine is of the ¼-in. high-speed solid-die double-blow type producing 150 components a minute, and incorporates a number of interesting features. The ¼-in. trimming machine is designed to give an output comparable with that of the cold forging machine, and again a number of new features are embodied. The ¼-in. inclined hopper-fed thread rolling machine is a standard model.

A 3-roll pyramid plate bending machine and a 60-ton press brake will be shown by BRONX ENGINEERING CO., LTD., on Stand D.236. The former is suitable for bending mild steel plate 10 ft. in width × ½-in. thickness, the main drive being a 16 h.p. motor, with an 8 h.p. motor for top roll adjustment. The capacity of the press brake is 8 ft. × ⅛ in. and 6 ft. × $\frac{3}{16}$ in. mild steel between the columns, and overall the beams, 10 ft. × 12 s.w.g. mild steel. These values are based on a die ratio of 8 to 1.

All the metal cutting machines on the stand of THE MIDLAND SAW AND TOOL CO., LTD. (B.228), will be available for demonstration. They will include an ATC toolroom bandsaw with saw welder incorporated; an AT toolroom bandsaw with saw brazer incorporated; a 36 in. variable high-speed bandsaw for sheet metal; an overhead cut-off machine for aluminium extruded sections; a 36 in., 8-speed bandsaw for cutting aluminium bronze, phosphor bronze, gun metal, brass and aluminium alloys; and an electric butt welding unit for saws up to 1 in. wide.

A newcomer to the range of crushing and grinding machinery made by BRITISH JEFFREY-DIAMOND, LTD., will be shown on Stand D.528. It is the Intermediate Atomill which is capable of providing products between 50 and minus 300 B.S. mesh, depending on the material,



Courtesy of W. & T. Avery, Ltd.

Type 7104 CCH universal testing machine.

in one pass through the machine. Other exhibits representative of the B.J.-D. range will include a 42 in. × 48 in. Flextooth crusher, a 36 in. × 36 in. Mark II single roll breaker; a 15 in. × 8 in. swing hammer pulveriser; a 15 in. × 8 in. Atomill fine grinder; and a Microid Atomill.

Typical of the large range of Kue-Ken crushers manufactured by SIR W. G. ARMSTRONG WHITWORTH & CO. (IRONFOUNDERS), LTD., the Model 35 (16 in. × 9 in.) jaw crusher and 18 in. gyratory crusher will be shown running light on stand D.235/136.

Small Tools and Tool Steels

The die steel exhibit on the EDGAR ALLEN stand (D.536) will show a range of steels for dies working on aluminium, copper-base alloys, etc., together with actual finished dies. A particularly interesting exhibit will be a brass pressure die casting made at the 20,000th shot in a four impression die in Edgar Allen's D.C.B. steel. A display of small tools will include standard, form-ground and hand-ground special Stag Major Superweld butt-welded tools, high-speed tools of various form-ground special types, and Athyweld deposit-welded tools, the principal items being roll turners' tools in 10–12% cobalt steel having a minimum Rockwell hardness of C.65, and form tools in the same material. There will also be a range of Stag Major high-speed steel tool-holder bits, Stag Major special design taper shank twist drills for drilling manganese and high tensile steels and 18% tungsten jobbers and taper shank drills.

The major part of Stand D.234 (RICHARD W. CARR & CO., LTD.) will be devoted to a display of a range of Motor Brand fine tool steels shown in the form of finished tools loaned by customers. The steels illustrated by these tools are suitable for plastic moulding, die-casting, hot extrusion, impact extrusion, punching, pressing, clipping, drawing, thread rolling, and for production tools such as gauges, collets, taps, drills, cutters, reamers, hobs, etc. There will also be a selection of Motor Brand engineers' small tools, while a further section of the stand will be used to illustrate the type of work carried out at the Company's Birmingham Heat Treatment Department.

The products of the ENGLISH STEEL CORPORATION'S Openshaw Works shown on Stand D.541/438 will be covered by attractive displays of engineers' cutting tools, which will include the new Easicut Blue drill, Easicut ground thread taps and end mills. Tool steels, files and hacksaws, and permanent magnets will also be on view.

A section of the DELORO STELLITE stand (D.402) will be devoted to a range of tipped and solid tools, milling blades, centres, workrests and cutters. Several examples of special tools and unusual tooling applications have been collected, and demonstrations will be given throughout the day of the Stellite hard steel drill.

Various examples of tools and dies manufactured from DARWINS special steels will be shown on Stand D.225/126, together with permanent magnet castings, toolbits and hacksaws. A particularly interesting exhibit will be the Cobaltcrom special abrasive resisting hacksaw blades, which have been re-introduced after a number of years, as an intermediary between the tungsten and high-speed steel types of blade.

Included in the tungsten carbide exhibits on Stand D.167, ANGLARDIA, LTD., will have on show lathe tools of standard and special shapes, tipped drills, reamers, end mills and milling cutters.

A general collection of engineers' cutting tools will be shown by FIRTH BROWN TOOLS, LTD., on Stand C.319, the composite stand of the GAUGE AND TOOL MAKERS' ASSOCIATION. Particular emphasis will be laid on the mechanics' pocket drill sets, of which there are four, comprising Speedicut high speed steel parallel shank drills in an aluminium box. Other exhibitors on this stand will include B.S.A. TOOLS, LTD., who will be showing drills, reamers, taps and dies, thread rolls, B.S.A.-Sintox* ceramic tipped tools, B.S.A.-Namco dieheads, high speed steel milling cutters, cast milling cutters, and a B.S.A. broach. The display of HALL & PICKLES, LTD., will comprise a range of engineers' small tools, Hydraweld tools, and Hydraloy tools—in both standard and special forms.

Among the WICKMAN WIMET DIVISION exhibits to be shown on the composite stand of the GAUGE & TOOLMAKERS' ASSOCIATION (C.319), will be the recently introduced range of Wimet tungsten carbide burs. These are available with diamond-lapped teeth in standard and fine cuts in a full range of commonly used sizes. Several examples of the applications of Wimet in toolmaking will also be seen, including a completed die set with solid Wimet punches and die segments for the production of razor blades.

Mechanical Testing Equipment

A range of testing machines will be shown by SAML. DENISON & SON, LTD., on Stand D.228. It will include a 50-ton self indicating universal testing machine, a 12,500-lb. self-indicating universal testing machine, a 15,000-lb. self-indicating tensile testing machine, and a 150-ton compression and transverse testing machine. Several machines for the measurement of creep at high temperatures will also be exhibited. Of special interest will be a new development in the form of a compression and transverse testing machine, of 10,000-lb. capacity, with constant rate of loading device for tests under B.S. 340, 368, 492, 1881 and C.P. 114. The weighing machines to be shown are referred to later under the heading "Miscellaneous."

The Avery 50-ton dial-indicating universal testing machine has found widespread application in research institutions, universities and technical colleges. A

* Product of Lodge Plugs, Ltd.

similar machine but of 100-ton capacity has now been developed and will be shown for the first time by W. & T. AVERY, LTD., on Stand D.523/420. It is designed for testing in compression, tension and transverse bending, and comprises two units—the straining unit for applying the load, and an indicating unit for measuring the load and for the accommodation of the pumps and control gear. The machine has sufficient rigidity for testing small structures with the degree of end constraint required by modern technique, and it can be fitted with a wide range of attachments and tools for special tests.

The testing machines to be seen on Stand D.632 (GEORGE H. ALEXANDER MACHINERY, LTD.) will include a Rockwell hardness tester incorporating the latest designs for simple and convenient operation and an Alexander sheet metal testing machine with a new range of auxiliary tools for deep drawing tests.



Courtesy of Saml. Denison & Son, Ltd.

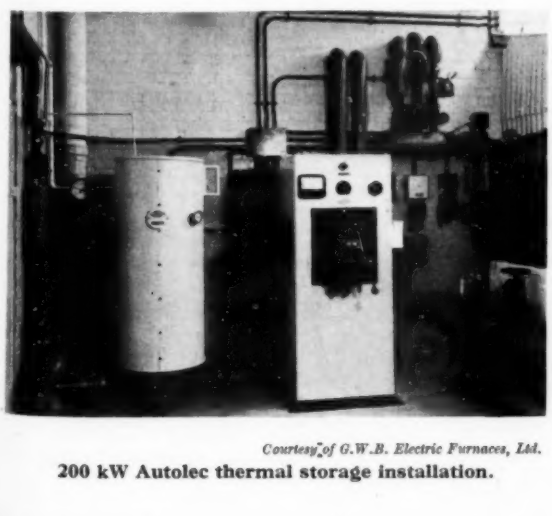
Patented suspended weigher

Electrical Equipment

The range of products made by the large electrical engineering concerns is so extensive that it is impossible for them to do more than pinpoint selected aspects of their activities. Moreover, certain types of plant are so large that they can only be exhibited in the form of photographs or models. The predominant feature of the display of METROPOLITAN-VICKERS ELECTRICAL CO., LTD., on Stand C.510 will be a single-phase on-load tap changer for use at the 132 kV terminals of a 120 MVA auto-transformer; the latter will be shown in model form. Other exhibits will include a 55 kV electron microscope; a mass spectrometer; a display of Metrosil; a flameproof motor fitted with Metrovick constant level lubricator; control gear; and a model of a 40,000 kVA synchronous condenser.

This year, the stand of THE GENERAL ELECTRIC CO., LTD. (C.503/402) will tell the story of lighting. This theme embraces practically every aspect of a branch of science which, although taken very much for granted to-day, is as much in the forefront of technical progress as its more spectacular counterparts in other spheres. The presentation follows the lines which research, development and application have taken since the early days of electric light—from the early carbon filament lamps to the present day discharge lamps and fluorescent tubes.

Three lines of industrial motor production will be featured on the ENGLISH ELECTRIC stand (C.613/512): the LY standard range; flameproof XLK motors; and KKS crane and hoist motors. Fusegear and switchgear will be prominently displayed, the switchboard to be shown being a typical medium voltage board suitable for industrial installation. Other exhibits will include transformers; a working model of a miniature depth indicator for a mine winder; rectifiers; and a comprehensive range of meters, relays and instruments.



Courtesy of G.W.B. Electric Furnaces, Ltd.

200 kW Autolec thermal storage installation.

The exhibits on Stand C.511/410 (THE BRITISH THOMSON-HOUSTON CO., LTD.) will range from an 11 kV, 250 MVA switchgear unit to industrial electric heaters and fractional horsepower motors. Working demonstrations will include Stacreep crane control; Emotrol motor control; and a high speed batch counter; Mazda lamps will also be featured, as will a scale model of a diesel-electric locomotive. The important part played by the Company in the design and manufacture of heavy plant for the steel industry will be shown by photographs, including a diorama of the B.T.H. main drives at Abbey Works.

A wide range of transformers, meters and measuring instruments will be featured by FERRANTI, LTD., on Stand C.615/514. Among the many items of interest shown for the first time will be the Pentland series transformers and chokes, which are a new departure in transformer construction; the Ferranti high-speed oscillograph; and the Ferranti high-speed tape reader, which has many applications in the field of communications.

Oils

Prominently featured on the stand of FLETCHER MILLER, LTD. (D.510) will be the cutting fluid range which covers the servicing of all metal cutting operations, whilst for machine tool lubrication there will be Veta, Gena and Almarine oils and greases. Drawing lubricants are included in the exhibits, as are materials for heat treatment, including surface hardening powder, box carburiser, and a range of Almarine quenching and tempering oils. Attention will be drawn to metal pretreatment by a display of degreasers, rust removers, and rust preventatives.

D.317/214, the stand of SHELL-MEX AND B.P., LTD., distributors for the Shell and Anglo-Iranian oil groups, is mainly designed as a meeting place for visitors and friends of the Company, and for the discussion of problems involving lubricants or fuels.

In addition to a complete range of lubricants,



Courtesy of Glass Developments Ltd.

The Ultrasonoscope in use on a welded specimen.

insulating oils and anti-rust media, there will be, on Stand D.534 (GULF OIL (GREAT BRITAIN), LTD.), a series of oils and compounds that have been evolved for the cold working of ferrous and non-ferrous metals. Of special interest will be drawing oil 140, for by its use it is possible to produce fine molybdenum wire by drawing at room temperature through diamond dies with outstanding die life. To aluminium fabricators, a range of drawing oils for rod, tube and wire in addition to rolling media will be of outstanding interest.

An interesting exhibit built into the stand of Esso PETROLEUM CO., LTD. (D.433/332) will be a mechanical "flow chart," whereby the refining stages of petroleum may be followed from the crude oil to finished products. The stand will be laid out for the reception of trade visitors, and technical representatives will welcome enquiries relating to the industrial usage of petroleum.

A wide range of refined mineral oils for industrial engineering and technical uses will be shown by MANCHESTER OIL REFINERY (SALES), LTD., on Stand D.333/230, together with illustrations of their uses. They will include lubricating oils, technical white oils, chemicals from petroleum and a range of specialised oil products, such as cutting oils and flaw detection inks. The last-named will be further described under the heading "Miscellaneous."

On Stand D.629 the theme will be the VACUUM OIL COMPANY's refining and marketing organisation throughout the world. An unusual feature of the display will be a working model, scale $\frac{1}{4}$ in. to 1 ft., of an air-lift Thermofor catalytic cracking unit, the original of which is part of the new Vacuum refinery at Coryton, Essex. The main function of the stand will be to service as a meeting place where Vacuum engineers can discuss problems of lubrication, etc., with industrial management.

A full range of graphite greases, including a high-temperature grease specially designed to stand up to temperatures of 400° F., will be shown on Stand C.202 by C. R. AVERILL, LTD., along with a quick action graphited oil, a solid graphite lubricating stick, and a colloidal graphite concentrate for mixing with oil or petrol.

Miscellaneous

A range of Autolec electrode steam raisers and water boilers will be displayed by G.W.B. ELECTRIC FURNACES, LTD., on Stand C.321, the largest being 800 kW capacity, and the smallest 15 kW. Of particular interest will be a flow diagram illustrating the application of an Autolec water boiler to a thermal storage system. The installation, which is automatic in operation, consists of a boiler, together with ancillary switchgear, pumps and storage tanks, the latter being filled with hot water during the off-peak hours for use in daytime for space and process heating.

No less than 22 items of Tornado fan equipment will be shown by KEITH BLACKMAN, LTD., on Stand D.755/654, and the applications covered will include ventilation, dust extraction, boosting gas and air pressures, cupola blowing and space heating, whilst the man-cooling fan will be of particular interest where work has to be carried on under conditions of excessive heat.

Pneumatic dust control equipment designed and manufactured by DALLOW LAMBERT & CO., LTD., will be represented on Stand D.539. An outstanding feature in the unit dust collectors will be the Dustmaster range, shown for the first time at the B.I.F. This is an entirely new type of unit dust catcher possessing a number of unique features. Multiple connection installation work will be illustrated photographically. These plants are provided with varying separating media, from the more conventional type of cyclone to Drytube fabric type filters and Multiswirl wet collectors.

Interesting features of the ultrasonic flaw-detection equipment to be shown by GLASS DEVELOPMENTS, LTD., on Stand D.412, include a single probe accessory; miniature probes for the searching of small specimens and the detection of flaws up to $\frac{1}{8}$ in. below the surface; barium titanate probes, which give greater power than quartz probes and provide shorter pulses of ultrasonic energy; and steerable beam probes. Among the advantages claimed for the last-named are: the facility for rapid determination of the orientation of flaws; the fact that the angle of the beam can be varied enables these probes to replace the wide range of fixed angle probes necessary for a complete search of large specimens; and the fact that a wide area can be searched from one surface position.

The principal exhibit of CONVEYANCER FORK TRUCKS, LTD., on the joint stand of the OWEN ORGANISATION (D.717/616), will be the model E2–20, a three-wheel battery electric model, specially suited for operation in narrow aisles, between factory process points and other confined spaces. This truck is also ideal for loading and unloading rail vans, and road transport vehicles.

Representatives of a range of hydraulically-operated tube diaphragm pumps will be featured on Stand D.747 by MERRILL PUMPS, LTD. These pumps are suitable for handling chemical liquors, including pickling acids and plating solutions, as the fluid only comes into contact with a tube of chemical rubber, butyl, neoprene or polythene, and with internal fittings of ebonite, polythene, lead, porcelain or carbon. The models shown will include a 25 g.p.m. pump, and possibly one of 100 g.p.m. capacity. On the same stand, WYNN (PRODUCTS), LTD., will be exhibiting straight through diaphragm valves suitable for similar service.

The Mono pump has long been used in the handling of viscous fluids, but MONO PUMPS, LTD., have now extended their field of activity to the handling of dry materials, and the main exhibit of interest on Stand D.716 will, therefore, be a unit for handling dry

continued on page 205

It stands to reason...



. . . that after TWENTY-FIVE YEARS' practical EXPERIENCE of the applications of PHOSPHATE COATINGS widely in industry we have learnt a great deal about them . . .

. . . that we have developed new Processes* to meet fresh production demands (we now have TWENTY-TWO of them in daily use) . . .

. . . that our knowledge is readily available and immediately at your disposal . . .

. . . that you should consult us on any Metal Finishing interests you may have in the Industrial PHOSPHATING field.

* *in, of course, our well-known "PARKERIZING", "BONDERIZING" and "PARCO-LUBRIZING" ranges.*

THE PYRENE COMPANY LIMITED—METAL FINISHING DIVISION

Great West Road, Brentford, Middlesex

Telephone EALing 3444



Courtesy of Glass Developments Ltd.

The Ultrasonoscope in use on a welded specimen.

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It stands to reason...



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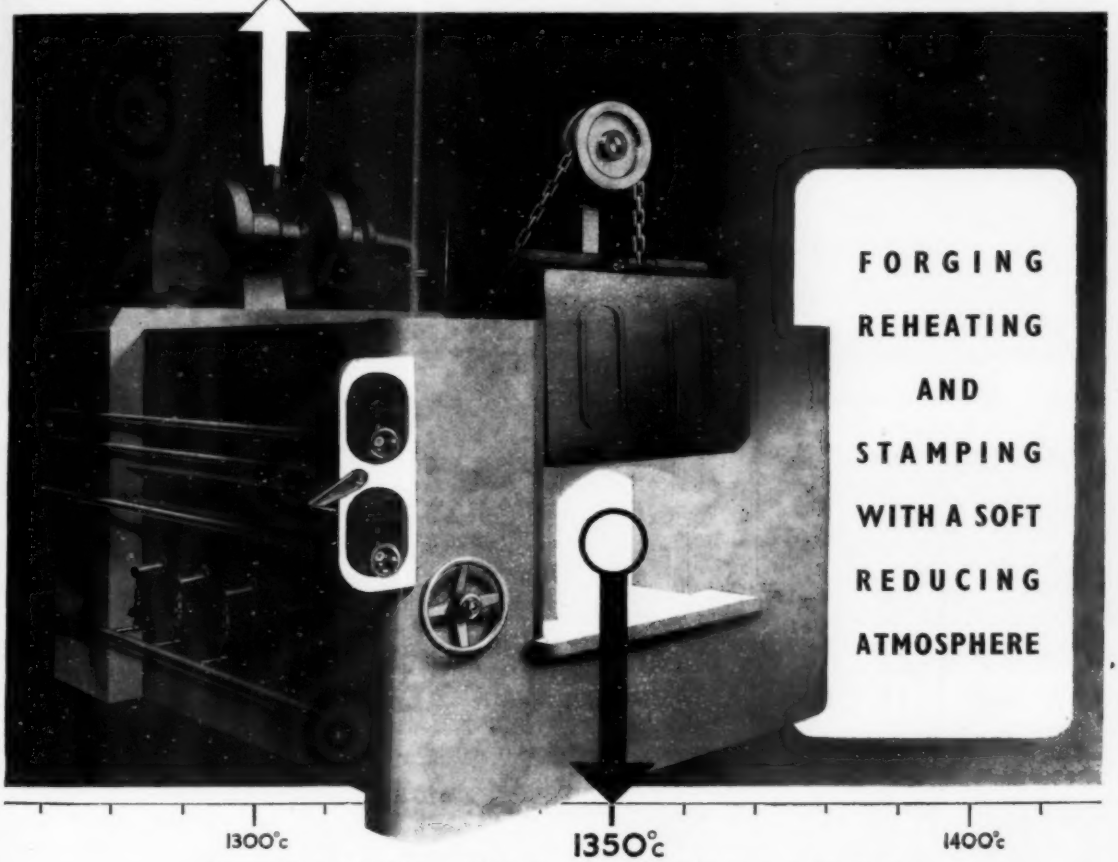
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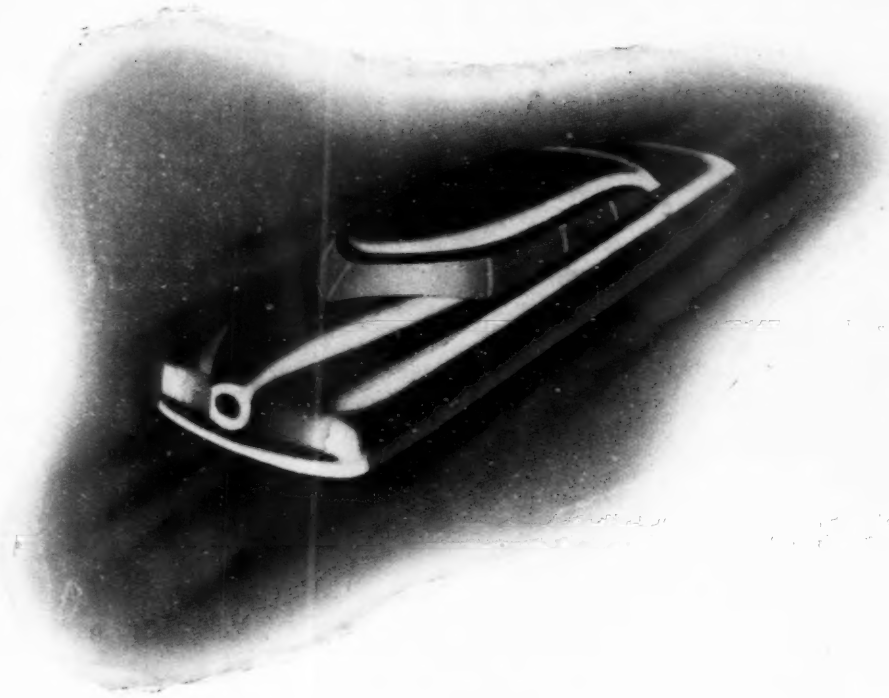


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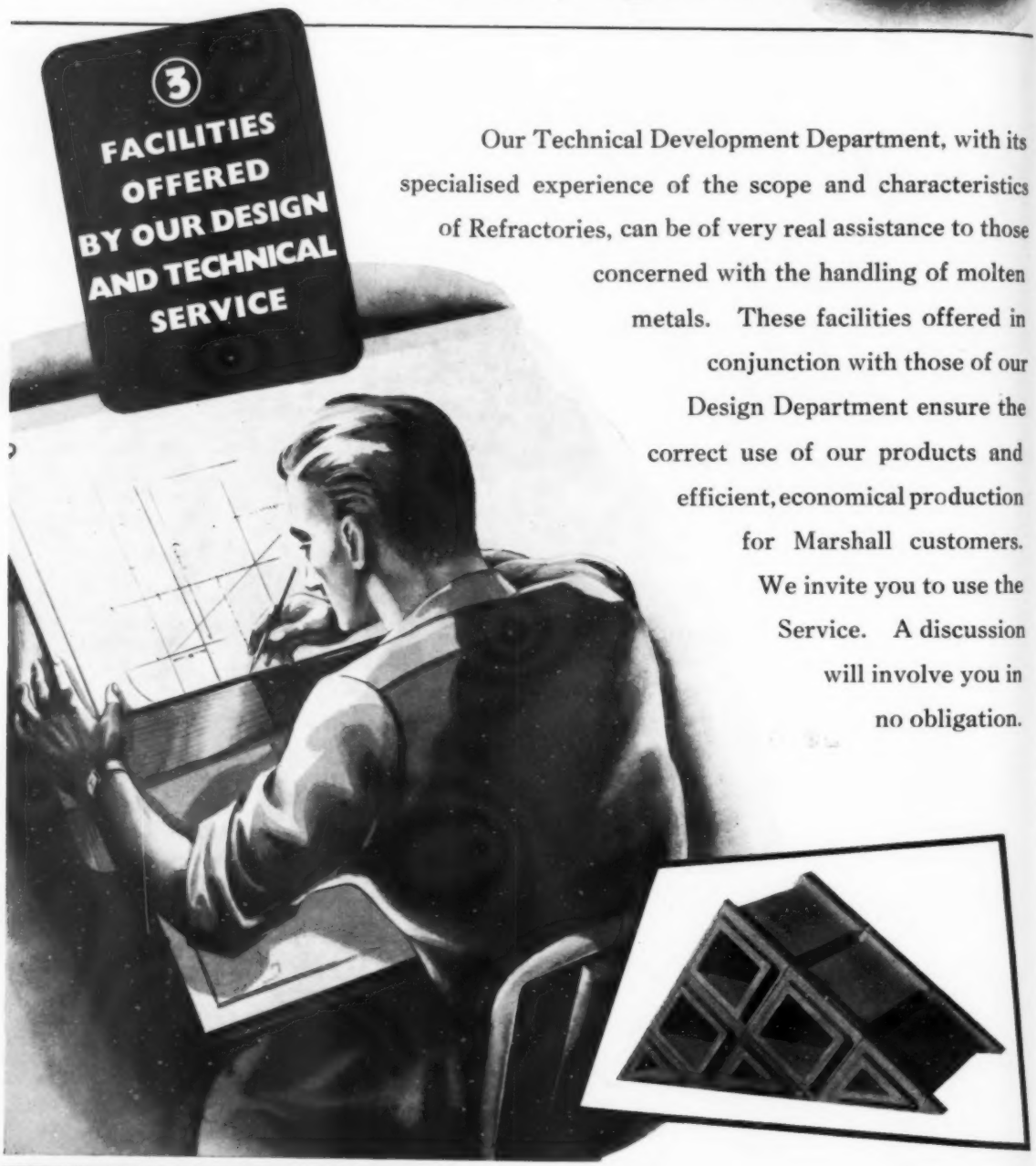


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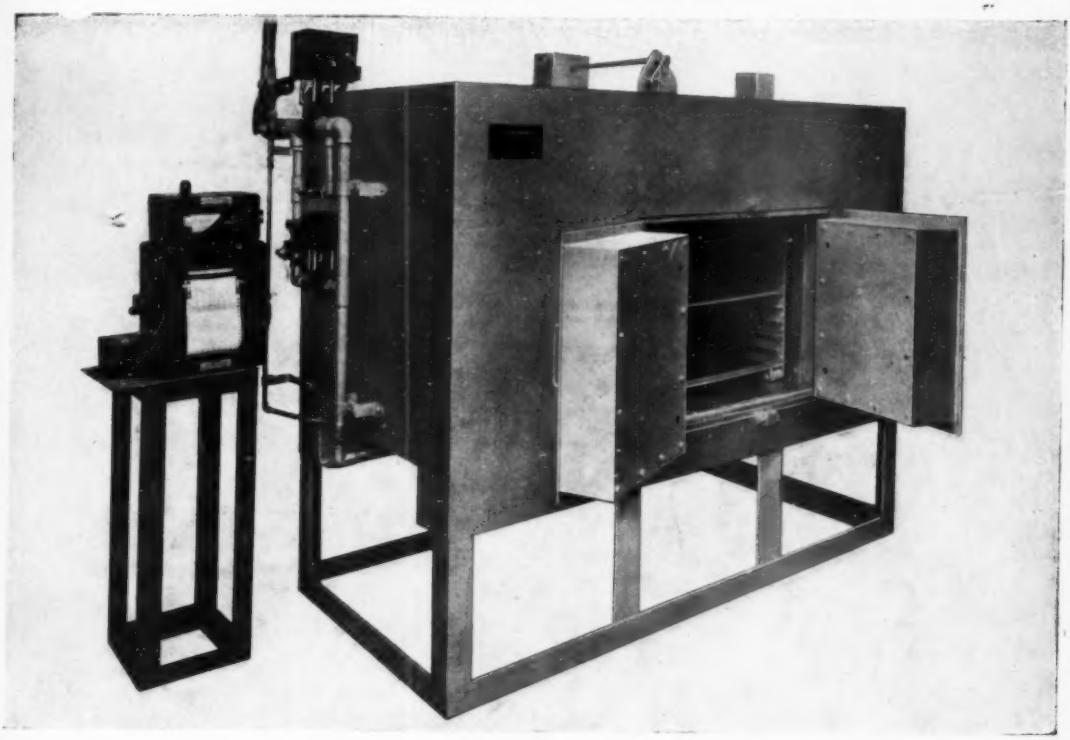
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The Production of Large Light Alloy Die Forgings

12,000-ton Press Installed by High Duty Alloy, Ltd.



The 12,000-ton press in operation. Here the billet is being settled in the die after the moving table has returned under the press.

THE possibility of using large forgings to replace units normally fabricated has been exercising the minds of aircraft designers and light alloy forgers during the last few years, and although much has been said and written during that period on the subject of large forging presses, and the part they have to play in the production of light alloy forgings for aircraft, no one has any actual experience in the matter, either here or in America.

The theoretical advantages of forging over fabricating structural parts are obvious. For instance, a complex assembly built up from numerous different pieces of rolled sheet, and stiffened by separately made flanges, could be replaced by a single forging which could be both lighter and stronger than the assembly. Before such a step could be taken, however, the spar or other structural component would have to be re-designed, with particular regard to the ease of production by forging. There is no doubt that the installation and maintenance costs associated with the large presses necessary for the production of such forgings would be high, but fabrication and machining are not usually cheap, and it may be that, technically and economically, many parts would show to advantage as pressings.

Dimensional Accuracy

The drop stamp has been proved by experience to be a very effective and relatively inexpensive unit for the production of large die forgings, but it is not a precision unit, and the greater dimensional accuracy attainable by using a hydraulic press is a big factor in favour of the latter. In comparing sizes, it is of interest to note that, within its special limitations, a drop hammer of 1 ton can be as effective as a hydraulic press of up to 1,000 tons.

As the overall dimensions of a die forging increase, a number of factors come more and more into play which can jeopardise the whole purpose of accurate close-to-form die pressing. These include thermal expansion and contraction of the press dies and pressed component; elastic deflection or plastic deformation of the press dies; elastic deflection of the press itself; distortion during removal from the press dies; and distortion of the pressed part during final heat treatment.

These and other factors suggest an upper limit for the plan area of a forging (including the flash), in present day high strength aluminium alloys, of some 2,000 sq. in., with an average thickness that could hardly be greater than 3 or 4 in. Using as a basis for calculation the figures arrived at by experience with small presses—10 tons/sq. in. for a simple pressing and 20 tons/sq. in. for a difficult pressing—this area calls for presses of 20,000–40,000 tons capacity. During the war the Germans made tapered wing spars of some 15 ft. in length on a 30,000-ton press, but attempts at 30 ft. spars were unsuccessful. However, they were sufficiently encouraged by their efforts to prepare designs for a 50,000-ton press.

U.S. Heavy Press Programme

In the United States, a 16,000-ton press was built in 1944 and used mainly to make jet engine impellers such as could have been made on an appropriate hammer. Since 1948 it has been used effectively to produce a great variety of structural shapes, some of which could hardly have been made on any other equipment. The current American heavy press programme consisting of two presses of 44,500 tons, four of 31,250 tons and two of 22,250 tons has been widely publicised, but the real potentials of such big presses are quite unknown.

It has been suggested that for simple shapes a press of 20,000–30,000 tons would be adequate, whilst for really difficult shapes a press of up to 40,000 tons would be



The main control panel from which the press is operated.

essential. It might be argued that a 50,000-ton press could do everything that a smaller press could do, and have something in hand to meet future demands. A reasonable answer to this is that a really large press is a very costly piece of machinery and many of the constructional details are revolutionary and, as yet, untried. Moreover, not only the press but all the ancillary equipment has to be on a larger scale. Smaller units although again untried, seem to offer the greatest chance of success, and a press of 30,000–35,000 tons capacity represents a logical and reasonable step from present standards.

H.D.A. 12,000-ton Press

The huge expenditure involved in the installation and operation of such large presses as these, coupled with the technical difficulties arising from their use and the uncertainty as to whether there would be a sufficient demand for their products, has led to a cautious attitude on the part of the aluminium industry of this country. Perhaps a firmer basis for consideration of the matter will result from experimental work on the 12,000-ton Loewy press installed recently, at a cost of £500,000, at the Redditch Works of High Duty Alloys, Ltd. In the meantime, this press will be engaged in the production of forgings for the engine side of the aircraft industry, its capacity permitting the production of the largest forgings called for in the jet engine field. Apart from the aircraft industry, the press opens up a new field for industry—cars, trucks, shipbuilding, locomotives and service equipment.

The press, which has been designed to give working pressures of 4,000, 8,000 and 12,000 tons, weighs 800 tons and has an overall height of 56 ft. 4 in. Of this, 42 ft. 9 in. is above ground level and the remainder, with the hydraulic system for operating the movable table, is concealed below ground level. Maintenance can be carried out on all this equipment by the removal of a section of the chequer plate which covers the area surrounding the press; ample room has also been left underground for the maintenance engineers to carry out their work. To form this underground chamber, 2,500 tons of soil was excavated, and to build the actual foundations for the press, 500 tons of concrete was poured in one continuous stream for 67 hours. The structural work above ground has meant the raising of the 220-ft. long roof from 40 ft. to 87 ft., and the erection of heavier stanchions to carry the tracks for the special 100-ton crane, which has also an auxiliary hoist of 25-ton capacity.

Adjacent to the press bay is located the new electrical sub-station, in which has been housed the two 1,500-kVA transformers together with all the high- and low-tension switchgear. The incoming electricity supply is 11,000 volts and is tapped from the main sub-station.

Other ancillary equipment consists of the accumulator unit—this has four treble ram pumps each driven through a reduction gear unit by 550-h.p. motors—a 6,500-gallon water storage tank, two water vessels and twelve air vessels; these last items are fed by two high-pressure compressors which maintain a pressure in the air vessels of 300 atmospheres. Interconnected to the accumulator system are two large pre-filling tanks.

continued on page 202



Three of the treble ram pumps in the accumulator system which are driven by 550 h.p. motors.

The Institute of Metals
Annual General Meeting in London

THE 1953 Annual General Meeting of the Institute of Metals was held in London from Monday to Thursday, March 23rd to 26th. The business meeting and the scientific and technical discussions were held at the Park Lane Hotel, as was the dinner-dance on the Tuesday evening, whilst an informal conversazione and exhibition was held on Wednesday evening at the offices of the Institute, at 4, Grosvenor Gardens.

The "May" Lecture now being incorporated in the Annual General Meeting, the forty-third of the series was given on the Monday evening in the Lecture Theatre of The Royal Institution, by Sir Christopher Hinton (Deputy Controller of Atomic Energy (Production), Ministry of Supply) on the subject of "The Present and Future Metallurgical Requirements of the Chemical Engineer."

Business Meeting

The official business of the Annual General Meeting was dealt with at a meeting on Tuesday morning, which was opened by the Retiring President, Dr. C. J. Smithells, extending to members and visitors, particularly those from overseas, a welcome to the Meeting.

The Report of the Council for the Year Ended 31st December, 1952, and the Report of the Honorary Treasurer and Accounts for the Financial Year Ended 30th June, 1952, were then adopted.

Officers for 1953–54.—The Secretary then announced the names of members elected to fill vacancies in the Council for the year 1953–54, as follows :—

President : PROFESSOR F. C. THOMPSON, D.Met., M.Sc., F.I.M. (Professor of Metallurgy, University of Manchester).

Vice-Presidents : MAJOR C. J. P BALL, D.S.O., M.C., F.R.Ae.S. (Chairman, Magnesium Elektron, Ltd.) ; PROFESSOR G. V. RAYNOR, M.A., D.Phil., D.Sc., F.R.I.C. (Professor of Metal Physics, University of Birmingham).

Ordinary Members of Council : MR. W. A. BAKER, B.Sc., F.I.M. (Research Manager, British Non-Ferrous Metals Research Association) ; MR. J. C. COLQUHOUN, M.B.E. (Chairman and Managing Director, The Manganese Bronze and Brass Co. Ltd.) ; MR. E. R. GADD, F.I.M. (Chief Metallurgist, Engine Division, The Bristol Aeroplane Co. Ltd.) ; THE HON. JOHN GRIMSTON, M.P. (Director and General Manager, Enfield Rolling Mills, Ltd.).

As previously announced, DR. S. F. DOREY, C.B.E., M.I.C.E., M.I.Mech.E., F.R.S. (Chief Engineer Surveyor, Lloyd's Register of Shipping) is to be Senior Vice-President for 1953–54 and he will be the Council's next nomination for the Presidency of the Institute.

Award of Medals and Prizes.—The Secretary announced that the Council has made awards of medals and prizes as follows :—

(i) *The Institute of Metals (Platinum) Medal for* 1953 to PROFESSOR GEORG MASING, of the Institut für allgemeine Metallkunde, Universität Göttingen, in recognition of his outstanding contributions in the field of metallography.

(ii) *The Rosenhain Medal for* 1953 to DR. CHARLES ERIC RANSLEY, of the Research Laboratories, The British Aluminium Co. Ltd., Gerrards Cross, in recognition of his outstanding experimental and theoretical work on gas-metal equilibria.

(iii) *The W. H. A. Robertson Medal for* 1952 *and a Premium of Fifty Guineas,* to MR. JOHN FRANCIS WAIGHT, of the West Midlands Gas Board, for his paper on "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," published in the *Journal of the Institute of Metals,* 1951–52, vol. 80, pp. 269–285.

(iv) *Students' Essay Competition Prizes for* 1952, to : MR. R. D. STACEY of the University of Birmingham, for an essay on "Some Experimental Evidence for Dislocations" and MR. G. THOMAS, B.Sc., of Cambridge University, for an essay on "Martensitic Transformations in Non-Ferrous Metals and Alloys."

The presentation of the medals and prizes, with the exception of the *Platinum Medal* (Professor Masing being unable to be present), was made by Professor Thompson following his Presidential Address, which is reported on pages 175 and 178.

Technical Sessions

Technical sessions for the presentation and discussion of papers were held on Tuesday afternoon, Wednesday morning and afternoon, and Thursday morning. Two concurrent technical sessions were held on the Wednesday, one of which took the form of an all-day symposium on "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys." Part I—"The Control of Quality in Melting and Casting." The papers presented at the various sessions are listed below :—

Tuesday Afternoon.

(1) Jointly : PHILLIPS (V. A.) and PHILLIPS (A.). "The Effect of Certain Solute Elements on the Recrystallisation of Copper" (December, 1952)* ; MEIKK-OJA. "Segregation of Iron and Phosphorus at the Grain Boundaries in 70 : 30 Brass during Grain Growth" (June, 1952).

(2) *Theme : Young's Modulus of Alloys.* Jointly : SMITH., "A Study of Some Factors Influencing the Young's Modulus of Solid Solutions" (May, 1952) ; and DUDZINSKI "The Young's Modulus, Poisson's Ratio, and Rigidity Modulus of Some Aluminium Alloys" (September, 1952).

Wednesday—Programme A (Symposium).

(1) SINGER. "The Principles of Technical Control in Metallurgical Manufacture" (March, 1953).

(2) COOK AND COWLEY. "The Control of Quality in the Production of Brass Ingots and Billets" (March, 1953).

(3) SYKES. "The Control of Quality in Melting and Casting Copper and High-Conductivity Copper-Base Alloys" (March, 1953).

(4) ROBERTS AND WALTERS. "The Control of Quality in the Casting of Zinc and Zinc Alloy Rolling Slabs and Extrusion Billets" (March, 1953).

(5) STAPLES AND HURST. "The Control of Quality in the Melting and Casting of Aluminium Alloys for Working" (March, 1953).

(6) WILKINSON AND HIRST. "The Control of Quality in Melting and Casting Magnesium Alloys for Hot Working" (March, 1953).

Wednesday—Programme B.

(1) *Theme : Corrosion of Alloys.* Jointly : BRENNER AND METCALFE. "The Effect of Cold-Work on the Microstructure and Corrosion-Resistance of Aluminium-5% Magnesium Alloys Containing 0·1% Zinc" (January, 1953) ; METCALFE. "Atmospheric Corrosion and Stress-Corrosion of Aluminium-Copper-Magnesium and Aluminium-Magnesium-Silicon Alloys in the Fully Heat-Treated Condition" (February, 1953) ; and ROBERTS. "Intercrystalline Corrosion in Cast Zinc-Aluminium Alloys" (February, 1953).

* Date of publication in the *Journal of the Institute of Metals.*

(2) *Theme : High-Temperature Oxidation of Alloys.* Jointly : PREECE AND LUCAS. "The High-Temperature Oxidation of Some Cobalt-Base and Nickel-Base Alloys" (December, 1952) ; and DENNISON AND PREECE. "High-Temperature Oxidation Characteristics of a Group of Oxidation-Resistant Copper-Base Alloys" (January, 1953).

(3) *Theme : Creep and Plastic Deformation.* Jointly : RACHINGER. "The Effect of Grain-Size on the Structural Changes Produced in Aluminium by Slow Deformation" (April, 1952) ; WOOD AND SUITER. "Stress-Recovery in Aluminium" (May, 1952) ; MCLEAN. "Creep Processes in Coarse-Grained Aluminium" (May, 1952) ; TROTTER "Electron-Microscopic Studies of Slip in Aluminium During Creep" (May, 1952) ; PUTTICK AND KING. "Boundary Slip in Bicrystals of Tin" (June, 1952); GREENOUGH, BATEMAN AND SMITH. "X-Ray Diffraction Studies in Relation to Creep" (June, 1952) ; RAMSEY. "The Recovery of Polycrystalline Aluminium" (October, 1952) ; BHATTACHARYA, CONGREVE AND THOMPSON. "The Creep/Time Relationship under Constant Tensile Stress" (October, 1952) ; JOHNSON AND FROST. "The Temperature Dependence of Transient and Secondary Creep of an Aluminium Alloy to British Standard 2L42 at Temperatures Between 20° and 250° C. and at Constant Stress" (October, 1952) ; MCLEAN. "Crystal Slip in Aluminium During Creep" (November, 1952) ; URIE AND WAIN. "Plastic Deformation of Coarse-Grained Aluminium" (November, 1952) ; SUITER AND WOOD. "Deformation of Magnesium at Various Rates and Temperatures" (December, 1952) ; RAMSEY. "The Sub-Grain Structure in Aluminium Deformed at Elevated Temperatures" (December, 1952) ; MCLEAN. "Crystal Fragmentation in Aluminium during Creep" (February, 1953) ; and MCLEAN. "Grain Boundary Slip During Creep of Aluminium" (February, 1953).

Thursday.

Metal Physics Session

An informal discussion on "Liquid Metals" arranged by the Metal Physics Committee, was introduced by DR. V. KONDIC (University of Birmingham) and DR. B. R. T. FROST Atomic Energy Research Establishment, Harwell.

Works Visits

The programme arranged for the Annual General Meeting was concluded by a series of visits to works and laboratories in the London region. They included an all-day visit to Vickers–Armstrongs, Ltd., Weybridge, a morning visit to the British Non-Ferrous Metals Research Association's Laboratories, a morning visit to The Pyrene Co. Ltd., Brentford, and an afternoon visit to Hoover, Ltd., Greenford.

The Production of Large Light Alloy Die Forgings

continued from page 200

To serve the press with pre-heated billets, there are three 30-ft. gas-fired furnaces, each having a capacity of 10 tons. Firing is indirect and none of the products of combustion enters the muffle. Each of the furnaces is divided into five zones and their individual temperatures are controlled in a special instrument room, which has been built into the main bay.

Structural Details

The press itself has two bedplates each weighing 14 tons. These were fastened down by special bolts which were anchored and placed in position whilst the concrete foundation was being poured. On these bedplates are located four adjustable plates recessed to contain and position the ends of the four supporting columns, each of which is 31 in. in diameter, 44 ft. 9 in. long and weighs 53 tons. These four columns serve a dual purpose : they pass right through the lower platen, through the moving crosshead, finally fixing above the top platen, thereby acting as a tie to the whole of the press ; their second function is to provide the means of carrying and guiding the crosshead.

The lower platen is made up of three castings, the centre section (weighing 64 tons) and two side sections (42 tons each), are dowelled, dovetailed and bolted together to form one piece. It is the centre section which forms the bed on which the hydraulically controlled moving table travels and on which the bolster and bottom forging, or pressing die, is fixed. On the lower face of the moving crosshead (weighing with its bushes 108 tons) are the necessary spigot recesses and tee slots for locating and fixing the top bolster and forging or pressing dies.

Motive power is provided to the crosshead by three hydraulic rams, each of which is 4 ft. 3 in. in diameter, 15 ft. long and weighs 28½ tons, operating in separate cylinders weighing 36 tons each and fixed in the upper platen. The upper platen is very similar to the moving crosshead in size and shape and weighs 94 tons. On this is mounted a buffer vessel which acts as a shock absorbe into which the pressure is released before entering the pre-filling vessels.

Method of Operation

The main movements of the press are controlled by one lever mounted on the main control panel. The first forward movement from the neutral position takes up the idle stroke, using pre-filling pressure only (approximately 40 lb./sq. in.) from two vessels provided, and the dead weight of the crosshead and rams. By moving the lever to the second position, pressures of 4,000, 8,000 or 12,000 tons can be exerted. If the lever is returned to the neutral position the load remains static, but by pulling the lever still further back the pressure is released into the buffer or shock-absorbing vessel, and the crosshead is lifted by the two return cylinders.

There are two other controls, one of which operates the moving table and another the ejector mechanism. These two are interlocked so as to prevent movement of the table whilst the ejector is in the up position.

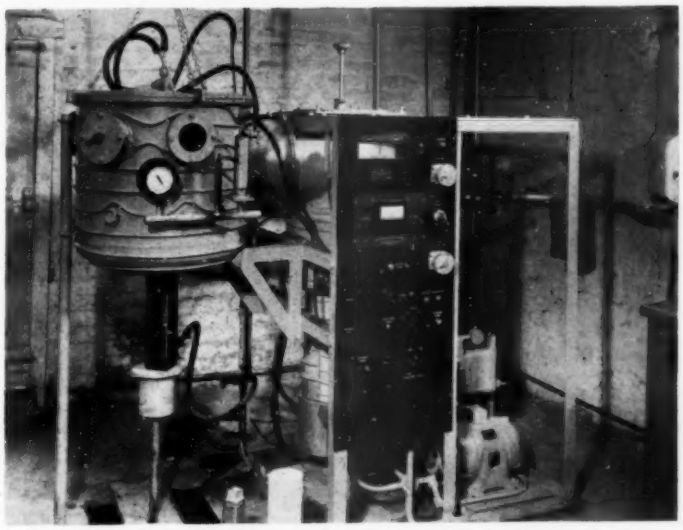
All the hydraulic system is controlled automatically by various electrical circuits and devices which operate the by-pass valves and start or stop the pressure pumps. Safety controls have been incorporated so that should the water drop below a minimum level, a low-level stop valve is automatically shut and no water can be taken from the bottles until the pumps have raised it to its normal working level. In addition to this precaution, a warning siren comes into operation. However, should the position be reversed and the water level be too high in the bottles, thereby increasing the pressure above the normal 300 atmospheres, a hooter sounds and will continue to do so until normal pressure is restored. The entire system is under constant surveillance from the control position through an illuminated indicator panel which shows by means of coloured lights what pumps are on load and the position of the low-level valve.

Non-Ferrous Metals Research Progress

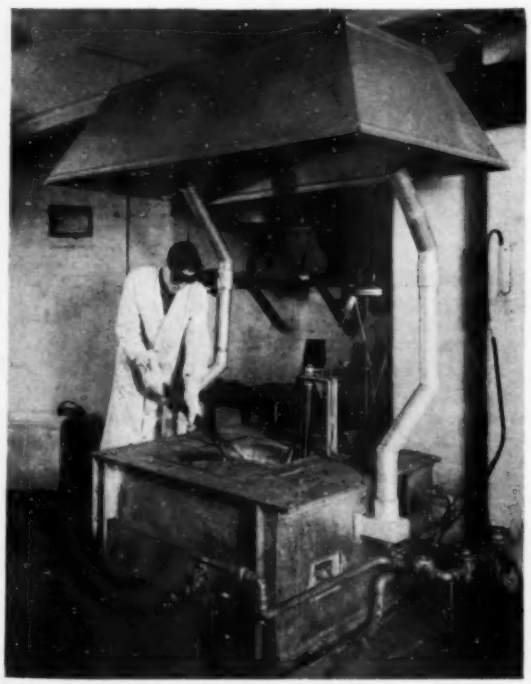
B.N.F.M.R.A.'s Laboratories Opened to Visitors

IN the three years which have elapsed since Sir Ben Lockspeiser opened the new laboratory block at the headquarters of the British Non-Ferrous Metals Research Association in London, the new building has been brought into full use and the additional facilities have enlarged the scope of the Association's research activities. Started in a very modest way in 1920 with a membership of only 20 firms and an income of less than £6,000, the Association has established itself as an integral part of the non-ferrous metals industry, and to-day has nearly 600 member firms at home and in the Commonwealth, and an income of about £128,000.

The Association offers its members three main services. First, a laboratory and organisation for conducting co-operative research and exchanging technological information. Second, a free, confidential consulting service to give assistance with individual technological problems. Third, an up-to-date information service and library covering the world literature on non-ferrous metallurgy. The extensive use of these services is a mark of members' appreciation of the advantages afforded by modern research and technology. Nevertheless, it is a cause for reflection that, although almost all the major firms in the non-ferrous metals industry are members, including many engineering firms who are merely users of non-ferrous metals, there are still many small and medium firms in the industry who do not take advantage of membership. In many cases, it is these firms who would benefit most from wise use of the facilities the Research Association provides.



Electric furnace for melting and casting under high vacuum.

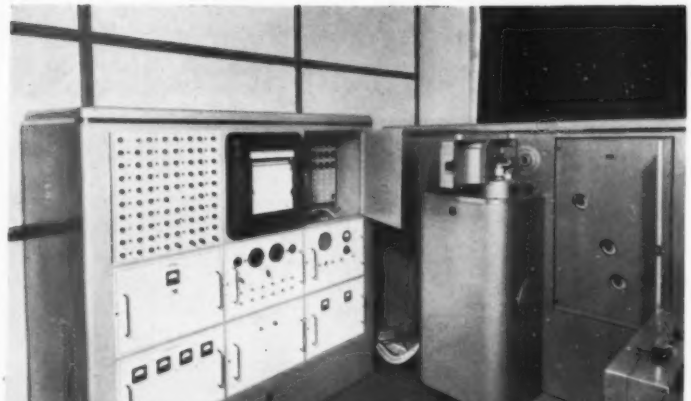


Controlled temperature bath for experiments on galvanising and other hot-dip coating processes.

To take just one example, it has been estimated that there are over 1,000 brass and bronze foundries up and down the country, but not more than 5% of these belong to the Research Association. Yet the Association is well known for its researches into non-ferrous foundry practice and could undoubtedly give much needed technical assistance to all these foundries. Only recently, the Association has been responsible for the introduction into the foundry industry of a special insulating feeder sleeve which cuts production costs by using less metal to make sound castings. These sleeves are made from a newly developed foamed plaster of Paris which is as permeable as sand. They are inexpensive and enable the yield of metal melted compared to the weight of finished casting to be increased in some cases from about 50% to 80% or more.

There is scope for a lot of work of this kind, but it can only be carried out to the extent to which the industry is prepared to finance it. Membership subscriptions are not high. A small or medium sized firm is not usually asked to pay more than £50 per annum and there are arrangements with several trade associations whereby small firms can join at an even lower subscription.

Metallurgy is now a complex branch of science



The Quantometer direct reading spectrometer and recorder.

drawing on the knowledge of the physicist, chemist and engineer as well as the metallurgical specialist. Few firms can afford to maintain specialists in all these branches of science and the expensive equipment they need for research work. Yet all these specialists, and all the latest scientific techniques are available to even the smallest member through the resources of the Research Association. In addition, the Association maintains a team of men experienced in the interpretation of modern research who can, and do, assist members to take full advantage of the latest developments in technology and research.

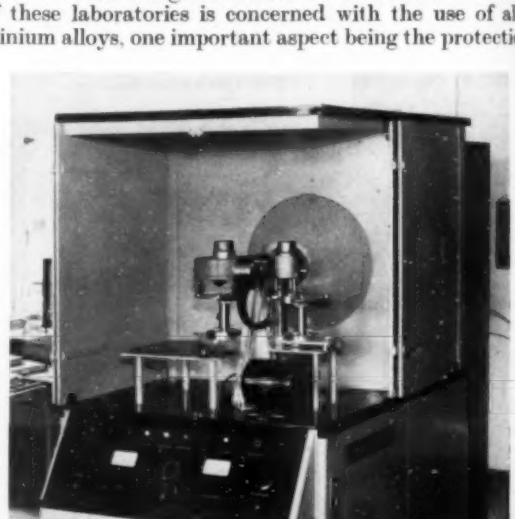
Researches in Progress

Researches in progress at the moment range from homely subjects like the effect of the new washing detergents on zinc alloy diecastings used in washing machines, to more spectacular ones like the evaluation of the properties of titanium and its alloys—a new metal as strong as steel but only half as heavy. This metal has a very high melting point (1,700° C.), and in the Association's laboratories it is usually melted in an arc furnace, in vacuum or in an atmosphere of argon. It is so reactive that it alloys readily with the oxygen and nitrogen of the air, or with carbon if this is used for melting pots. These elements can all act as hardening agents in titanium, so that it is important to know whether they are present, and to what extent. The laboratories have a section specialising in the analytical techniques needed for determinations of this kind, including the vacuum extraction and analysis of the gases present in metals.

The prevention of corrosion, the enemy of all metals, naturally plays an important role in the Association's research programme. It is no exaggeration to say that the successful working of the marine steam turbine depends to a large degree on the research work on condenser tube materials carried out in these laboratories over the past 25 years. The tubes in these condensers are subject to an intense form of corrosion by the fast flow of sea-water needed to cool the exhaust steam, and in the First World War naval vessels lost much time in port through the failure of condenser tubes. The condenser tube alloys developed since then virtually eliminated this trouble in the last war. New problems have arisen where these tube materials are in use in power stations and oil refineries built on river estuaries in which the water is heavily contaminated with industrial waste and further research is in progress.

Outside the field of marine corrosion an extensive investigation has just been made into the failures of copper domestic water pipes through pitting corrosion which occurs occasionally in a few parts of the country. This pitting corrosion has been found to be due to a peculiar combination of circumstances—the presence of a carbon deposit on the inside of the copper tubes together with the absence of an organic substance normally present in small amounts in most water supplies. This organic compound has the effect of stifling corrosion, although in its absence corrosion once started can go on unhindered. The identification of this compound would allow of its addition to all water supplies, but so far its composition has defied analysis. All that can be done at present is to test for the presence of the compound to see whether the water is likely to support the pitting corrosion of copper, given the right conditions for the initiation of corrosion.

Other work being carried out in the corrosion section of these laboratories is concerned with the use of aluminium alloys, one important aspect being the protection



High power rotating anode X-ray generator for crystallographic examination (based on Mond Nickel Research Laboratories' design).

of aluminium-sheathed electric cables where they have to be buried underground.

Metal Economy

During the last two or three years, the Research Association has naturally become involved with problems arising from the shortage of both non-ferrous metals and sulphuric acid used for pickling metals during processing. In the latter connection, practical recommendations were made for economising in the consumption of sulphuric acid and, incidentally, to save copper at the same time. The Association was also in a strong position to advise on measures to help the galvanising industry through the zinc shortage. From the basic knowledge of the galvanising process which had been established as a result of past research work, suggestions were made for reducing the consumption of zinc without detriment to the quality of the galvanised article. The Association's staff put these recommendations into practice in one firm's works and reduced zinc consumption by about 15%. The methods used were then demonstrated to other member firms in this industry—a fine example of co-operative work.

The zinc shortage was only temporary, but nickel is still scarce. The Research Association is assisting here in two ways. First, by acting as a test-house for evaluating the several substitutes for nickel plating that have been put forward. Second, by carrying out research to improve the quality of electroplating so that thinner, but equally protective, nickel coatings may be produced. The metal finishing section of the laboratories is also working on the electroplating of light alloys. Several methods of plating on aluminium have been exhaustively tested and there is good reason to expect that one of the processes at present used commercially in a limited way can be considerably simplified and improved to form the basis of an automatic plating installation. Such a development would enable greater use to be made of plated aluminium in the motor industry and for tableware.

New Materials of Construction

New engineering ventures, new methods of construction, bring new problems for the metallurgist in their train. The increasing use of aluminium alloy pressings, for example, for panels in aircraft, motor cars, refrigerators and so on, revealed the susceptibility of some of these alloys to strain markings which mar the appearance of the pressings—a problem already well known in the steel industry—and the Association has had to develop ways of suppressing this effect by such means as controlling the grain size of the material or finishing the sheets by a special light rolling and heat-treatment schedule. The evolution of the gas turbine has led to a demand for alloys to resist corrosive conditions at high temperatures. A group of copper alloys—the aluminium bronzes—which can easily be forged are being used extensively as compressor blades in these engines, and the long-term properties of these alloys at high temperatures have had to be established to provide data for the turbine engineer.

The Quantometer

The Association has long held a leading position in the field of techniques for the spectrographic analysis of metals—a rapid method of analysis in which the composition of a metal is determined from the intensity of the lines in the spectrum which is produced when an electric discharge is passed between a rod of the metal and another electrode. To the existing three spectrographs in the laboratories, there has recently been added an American Quantometer—a direct reading spectrograph capable of estimating up to 16 elements in a given sample within a matter of a few seconds. The instrument, which occupies a whole room, is being used to develop methods for the analysis of copper and its alloys, a use to which it has not previously been applied.

Among other "electronic" equipment possessed by the laboratories is an electron microscope capable of magnifications up to 100,000 times, electron-diffraction equipment for identifying surface films on metals and X-ray equipment for investigating crystal structure.

The laboratories also contain a foundry, rolling mill, draw-bench, forging and extrusion plant, as well as the more usual metallurgical, chemical and corrosion testing facilities.

British Industries Fair

continued from page 198.

powdered or granulated material. Other working exhibits on the stand will include a D.4 pump handling a heavy viscous grease, and an IBD15 wet vacuum pump. The range of Mono Pumps exhibited on the stand will cover the H type stainless steel pumps, and ebonite lined D types for handling plating solutions.

Of particular interest to the metal industry will be the three flaw detecting inks shown by MANCHESTER OIL REFINERY (SALES), LTD., on Stand D.333/230. Two of them are for use with magnetisable materials, one being fluorescent, while the third is a fluorescent penetrating ink suitable for both magnetisable and non-magnetisable materials.

The 55kV electron microscope, type EM4, to be shown by METROPOLITAN-VICKERS ELECTRICAL CO., LTD., on Stand C.510, has been designed as an inexpensive instrument for routine work. It will provide magnifications up to × 12,000 with a resolution better than 100Å. A special feature is the easy adaption for reflection electron microscopy.

Among the weighing machines shown by SAML. DENISON & SON, LTD., on Stand D.228, will be a Blake-Denison conveyor belt totalising weighing machine and a number of suspended weighing machines. The latter are of special interest, being made on the knife-edge and weighing lever principle.

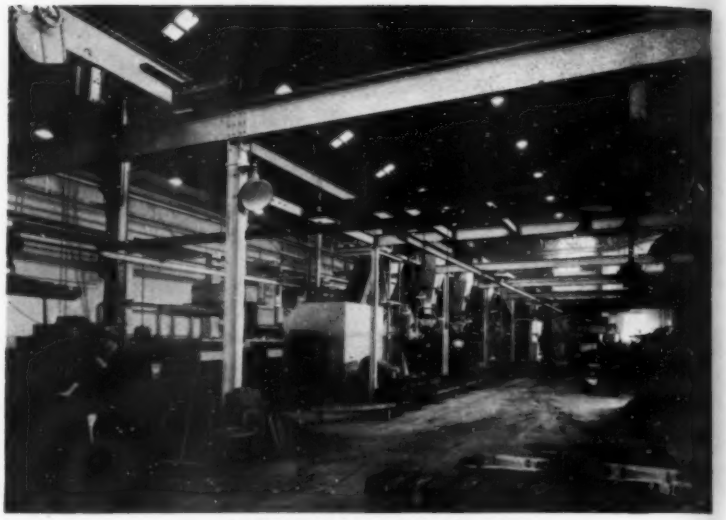
Believing that prevention is better than cure, ROZALEX, LTD., are now in a position to provide a barrier cream that will guard against most of the known causative agents of dermatitis. Two types of cream, for wet and dry work, respectively, will be shown on Stand D.706, along with the handy Rex dispenser.

A special feature of the stand of JOHN RIGBY & SONS, LTD. (D.607), will be a display of powder metal parts in brass, bronze, copper, nickel silver, iron, etc., whilst metal powders will be shown by MELLOR MINERAL MILLS LTD., on Stand D.159.

Apart from demonstrating new applications of Sigma multi-dimension inspection machines and Hilger projectors on Stand D.310, ALFRED HERBERT, LTD., will be demonstrating a number of new developments, such as the application of the Solus-Schall crack detector; the Hall micro-hardness tester; the Taylor-Hobson alignment telescope; and the Hilger turbine-blade projector.

Castings for Measuring Instruments

New Kent Non-Ferrous Foundry



A general view of the foundry.

THE visitor to the Luton works of George Kent, Ltd., who is thinking in terms of instrument manufacture may be surprised to see the selection of rather heavy iron and non-ferrous castings being handled in the machine shop. The answer is, of course, that one of the Company's principal activities is the manufacture of measuring and controlling instruments for water, steam, air, gas, oil and petrol, and for certain purposes it is necessary to have a calibrated restriction in the pipeline. This may take the form of an orifice plate, a Venturi throat, or a Dall tube, and in each case the making and calibrating of the restriction is an essential part of the instrument makers' job. The orifice plate and Venturi throat have been in use for many years, but the Dall tube is a recent development whose main advantage is that, for a given instrument-operating pressure differential, the overall loss of pressure due to the restriction is less even than that of the Venturi and, of course, much less than that of the simple orifice plate.

At one time, the Kent foundry produced both ferrous and non-ferrous castings, but the output is now confined to alloys of copper and aluminium, iron castings being purchased from outside suppliers. The manufacture of the meters referred to above, and of other industrial instruments, embraces many " purpose-made " devices, designed for a few specialised applications only in a limited field, and for which the chances of repeat orders are small. In other cases, the customer wants the standard product with his name or other special marks cast in—a requirement which is very common in the firm's large export market, in which early delivery is an important factor. In spite of all the deviations from standard, the market is sharply competitive and extremely high quality is demanded. Many of the castings have to be pressure-tight, and the compromise between high standards of finish, freedom from gas holes, and thin-walled castings for optimum weight, is difficult to attain. As a further complication, the plant is situated in an area where labour is scarce, especially for uncongenial work, and it has, therefore, been found necessary to exploit to the full recent developments in foundry technique, in spite of all the economic factors ranged against their use for this type of work.



Pouring brass from a Morgan tilting-type coke-fired furnace into a crucible supported by a Roper hoist. The steel doors behind the furnaces slide upward and are usually closed during pouring operations to stop cross-draught interfering with extraction.

Considerable advances in methods and in working conditions were made while the foundry was situated at the main Biscot Road works, but when the Lea Works in Luton was acquired by the Company it was felt that still further improvements would be possible by undertaking the task of removing the foundry to the new works. It was decided, therefore, that 20,000 sq. ft. of



Sand preparation plant. In the centre are two Pneulec mixing mills with vertical-loading skip hoist ; the control levers being on the left of the hoist. Above the levers, a 10-in. dial Kent water meter measures the water addition to the sand in the mill. The rotary screen over the bin on the right deals with used sand.

the total 63,000 sq. ft. of the new factory should be allocated to the foundry, and that the associated functions of pattern making, repair and storage should be amalgamated under one roof. As a consequence of these developments there is found in the new foundry a large proportion of the work on pattern plates for machine moulding ; roller conveyor tracks reducing the handling, work and cost ; and air-blown resin-bonded cores machine-made by semi-skilled labour. On the other hand, large Venturi throat castings weighing up to 3,000 lb. are moulded by strickle board and loam cores employed. The output of the new foundry is 15 tons per week in castings varying in weight from a few ounces to 3,000 lb. : some fifteen copper and aluminium-base alloys are regularly used.

Metal Melting

Metal is received and stored on steel pallets in a compound outside the foundry wall, from whence it is removed by a Ransome 1-ton fork lift truck which loads the pallets, through hatches in the wall, on to a platform covered with roller track, running the whole length of the row of furnaces. The height of the platform is such that ingots can conveniently be fed into the tops of the furnaces as required.

The copper-alloy melting furnaces comprise four 450-lb. Morgan units (coke-fired) and two 600-lb. Polford units (oil-fired), all of the tilting type. Ancillary equipment, fans, etc., are housed under the roller platform and separated from the furnaces by a brick wall, making for reasonable running conditions and easy maintenance. When melted, the metal is poured into 150-lb. plumbago crucibles, which are transferred to the mould pouring station by Roper hoists on King super-track mono-rail, with a convenient arrangement of loops and King track switches.

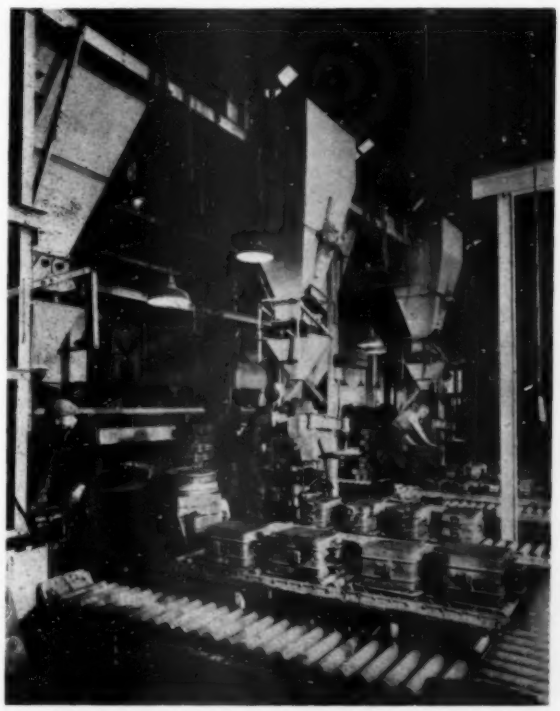
There is also a large output of aluminium alloy castings which are mainly floor moulded. Both bale-out and tilting furnaces are employed for melting aluminium ; they are oil-fired and of 200-lb. capacity.

The oil supply for the furnaces generally is contained in two 1,000-gallon underground tanks. It is pumped to two 100-gallon head tanks on the outside wall and thence is gravity fed to the burners. The fire hazard is covered by air-operated valves, held open by air pressure. When the foundry shuts down its air supply, the valves automatically close the oil supply. In an emergency, the whole oil supply is cut off by the operation of one air valve.

Sand Plant and Moulding Equipment

New sand, Bromsgrove Red, is delivered from road transport through a hatch in the wall into a bin adjacent to the used returned-sand bin. Sand in suitable proportions is conveyed by vertical-skip hoist to a breeches hopper and discharged into one of two Pneulec 6-cwt. batch mills, where water is added in measured quantity (determined by a Kent water meter) direct into the mills. A system of electric indicators and mechanical interlocks of Kent manufacture is operated by signal-box type levers and is designed to eliminate double loading and other mistakes on the part of the operator which so often play havoc with a plant. The operating time for the sand mills is about six minutes per batch.

The discharge from the mills is received by a Patterson & Hughes conveyor belt and delivered into overhead

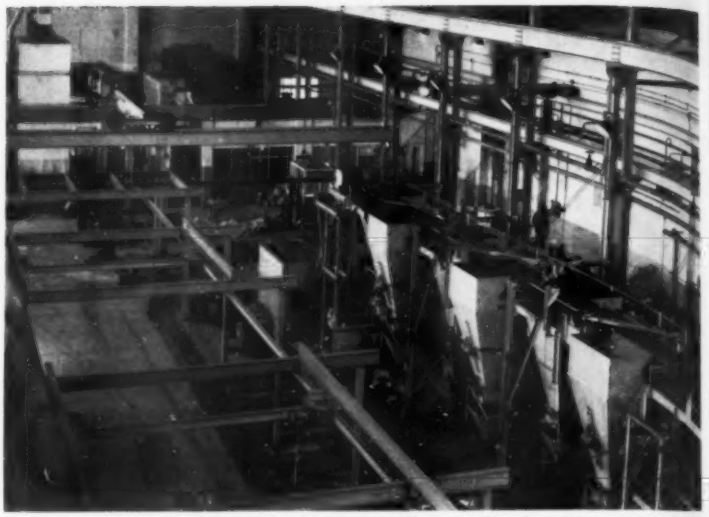


General view of machine moulding area, showing the arrangement of roller tracks and the sand supply system.

hoppers situated at each of the six moulding machines and also into a bin at floor level, for the use of floor moulders. A gangway is fitted beside the belt to facilitate maintenance and give access to the ploughs controlling the supply to each hopper. The belt has a delivery capacity of 15 tons per hour.

The moulding machines comprise two by Stone Wallwork and four by Eastern & Johnson (Zimmerman type) and are situated inside a continuous loop of Rownson heavy-duty roller track. Moulds are laid down, cored and capped on short lengths of track at right angles to the main loop, before being rolled on to the main track.

Pouring is carried out immediately in front of the line of furnaces and after a cooling period the moulds are pushed round to a Sherwen magnetic shake-out supplied by Fraser & Chalmers. The used sand passes through a grid, below floor level, on to an inclined conveyor belt, which, after passing a magnetic separator and negotiating a right-angle turn, discharges through a rotary sieve at high level. The effluent from the sieve is directed into two brick bins at floor level, one containing screened sand for re-use and the other cores, tramp metal, etc., for disposal.



General overhead view from the sand mill end, showing the sand supply belt and " ploughing off " arrangements at each hopper, and the bin for floor moulders' sand at the end of the belt. The vertical core oven is seen in the top left-hand corner.

The fettling section is installed immediately adjacent to the shake-out and is equipped with abrasive cutting-off machines and a bandsaw. Two Duplex stand grinders are employed for rough fettling, and shot-blasting is done in a tumbling-type machine by St. Georges Engineers and a cabinet shot-blast by Tilghman. Bench fettling is assisted by pneumatic chipping hammers of various sizes. Finished work and runners are taken away by Ransome fork truck or Collis jack-lift truck and steel pallets.

The Core Shop

Resin-bonded cores are air-blown by two 75-lb. Titan core blowers, and by British Ronceray cartridge-type blowers, whilst a number of cores are made in the usual wooden core boxes by girls. These cores are stoved in a vertical continuous conveyor oven made by the Foundry Engineering Company. Core sand is the Aylesford material from Maidstone, Kent, and it is now intended that, eventually, all sand preparation, drying, etc., shall be done on a mezzanine floor over the core shop so that supplies can be fed down hoppers to the benches.

Large loam cores are made as well, and are dried in a large brick-built core oven, heated by a C.R.A. unit supplied by Messrs. Foundry Refractories, Ltd., control of temperature being effected by means of Kent instruments. This oven is outside the main wall and at the end of the floor moulding section, and easy handling of the quite heavy weights is achieved by the use of a rolling axle bogey which runs into the oven. A two-ton electric and a hand gantry run across this area, giving assistance with both moulds and cores.

The core shop also deals with some special moulds, made, like cores, in oil sand in a number of pieces and assembled without the aid of loose sand. This method is employed for oil-meter castings.

Visiting Day

BIRMINGHAM employees of Northern Aluminium Co., Ltd., were able to show their friends and relatives the working of a modern light alloy foundry and forge in the course of a recent Open Day at the Company's plant at Middlemore Road, Handsworth. Though Saturday is not normally a working day, many employees were at work to enable representative processes to be carried on in all departments. Rather more than 500 people made the tour of the works and saw the film " Packaged Power " and an exhibition designed to relate what they had seen in the works with the final uses to which the metal is put, and with other branches of the aluminium industry. This was the first Open Day to be held at the Handsworth Works, which has recently been modernised and re-planned, but it is likely that it will become a regular event in the future.

New B.I.C.C. Company in Australia

BRITISH INSULATED CALLENDER'S CABLES, LTD., announce that their plans for the formation of a subsidiary company in Australia have been completed, the company having been registered in Victoria with the name British Insulated Callender's Cables (Australia) Pty. Ltd. The new company will take over the existing branches and will co-ordinate the activities of agents, the principal objects being to produce a greatly strengthened and expanded selling and technical service organization, and to co-ordinate the many important trading interests of B.I.C.C. The company will also engage in construction and installation work in collaboration with British Insulated Callender's Construction Co., Ltd., who have already large contracts in Australia for railway electrification, overhead lines and power cable installations.

NEWS AND ANNOUNCEMENTS

Iron and Steel Institute

Annual General Meeting

THE Annual General Meeting of the Iron & Steel Institute will be held on Thursday and Friday, 30th April and 1st May, 1953, at the Offices of the Institute, 4, Grosvenor Gardens, London, S.W.1.

It will be preceded by a Special Meeting on "Boron in Steel," which was to have been held on February 18th to discuss recent developments in the U.S.A. in the manufacture and use of boron-bearing steels, and will now be held on Wednesday, 29th April, at 4, Grosvenor Gardens. Papers will be presented by MR. H. ROHL of The United States Steel Corporation, MR. H. B. KNOWLTON of The International Harvester Company, and MR. H. WILLCOCK of The United Steel Companies, Ltd.

On April 30th, following the business meeting and induction of the new President, MR. JAMES MITCHELL, technical papers will be discussed at both morning and afternoon sessions. Further technical sessions will be held in the morning and afternoon of the 1st May. The Annual Dinner will be held on April 30th at Grosvenor House, Park Lane, when LT.-GEN. SIR IAN JACOB, Director General of the B.B.C., will be the principal guest.

Awards

The Council of the Iron & Steel Institute announce the following awards :—

The Bessemer Medal for 1953—To Mr. R. Mather (Skinningrove Iron Co. Ltd.) for his distinguished services to the Iron & Steel Institute and to the industry.

The Sir Robert Hadfield Medal for 1953—To Mr. W. E. Bardgett (Research Manager of the Central Research Laboratories of The United Steel Companies, Ltd.) in recognition of his contribution to the development of alloy steels, with particular reference to steels for service at elevated temperatures.

An Andrew Carnegie Silver Medal for 1952—To Dr. E. T. Turkdogan (now with B.I.S.R.A.) for his research on the slag metal reaction, reported in papers written in collaboration with Dr. W. R. Maddocks.

The Ablett Prize for 1952—Jointly (£50 each) to Dr. S. A. Burke and Mr. G. A. Sparkham (British Coal Utilisation Research Association), for their paper on "Automatic Control of Coal Feed in Steel Works' Gas Producers."

Presentations will take place at the Annual General Meeting at the end of this month.

Heat Treatment Practice Conference

PRELIMINARY notice is given by the British Iron and Steel Research Association, of a conference on Heat Treatment Practice to be held on June 15th, 16th and 17th next, at Ashorne Hill, Leamington Spa. It is intended that there shall be papers and discussion on the heat treatment of engineering steels and large forgings and sections, surface treatments, isothermal heat treatment, and temperature measurement and control. The conference, which is being organised by the Metallurgy (General) Division of the Association is expected to provide a meeting ground for engineers and steelmakers affected by these problems. Anyone wishing to attend should apply to Mr. A. M. Sage, British Iron and Steel Research Association, 11, Park Lane, London, W.1.

Cold Extrusion of Steel

S.A.S.M.U.T.A. Conference

THE cold extrusion of lead, tin and aluminium has been practised on a large scale for many years, but it was only about 1935 that Liebergeld in Germany tried to adapt the process to steel. During the war, the Germans achieved a certain measure of success, and after the cessation of hostilities the process was introduced into the U.S.A. where, with the aid of German technicians, the process has been put to use. Details of the technique are, however, not adequately available and no information exists as yet to make clear what are the requirements to make the difference between success and failure. The possibilities of the process are now engaging a number of organisations, as it appears that its adoption would lead to a considerable saving in steel and to the production of a higher grade product. It is too early to prophesy what its effect will be upon manufacturing processes in general, but in response to a demand from its members for fuller information, the Sheet and Strip Metal Users' Technical Association has arranged a two-day conference on the subject, to be held on 12th and 13th May, 1953, in the main hall of the Royal Empire Society, Northumberland Avenue, London, W.C.2.

The various problems associated with the cold extrusion of steel will be dealt with in a range of papers to be presented at this conference. The principle and practice of the cold extrusion of steel will be dealt with at the opening session by Dipl. Ing. H. Fischer (Kabel and Metallwerke Neumeyer, A.G.), while power presses for cold extrusion will be discussed by Mr. A. E. Clements (Clearing Machine Tool Corp., U.S.A.) and Mr. E. V. Crane (E. W. Bliss Corp., U.S.A.). Die steels play an important part in cold extrusion and a paper on the subject will be presented by Mr. E. Bishop (B.S.A. Group Research Centre) and Mr. E. Johnson (Wm. Jessop and Sons, Ltd.). Mr. H. A. Holden (The Pyrene Co. Ltd.) will then review the use of phosphate coatings to assist cold extrusion, whilst Dr. D. V. Wilson (Dept. of Industrial Metallurgy, University of Birmingham) will, at the final session, discuss the metallurgical requirements of steels for cold extrusion.

Full details and application forms for tickets are obtainable from the Hon. Secretary of the Association, 49, Wellington Street, Strand, London, W.C.2.

Welding Course

IN addition to courses for welding operators and for designers and draughtsmen, The Quasi-Arc Co., Ltd., have courses for welding engineers, supervisors, inspectors and foremen. About half the time is allocated to technical and theoretical work and half to practical welding experience. The next three weeks' course

begins on July 13th, and a further one on October 5th. Applications for enrolment should be sent to The Quasi-Arc Co., Ltd., Bilston, Staffordshire, or Bridgewater House, Cleveland Row, St. James's, London, S.W.1. Local accommodation can be arranged near the Bilston Works where the courses are held.

Tocco Director's Visit

DR. H. B. OSBORN, Technical Director of the Ohio Crankshaft Company, Cleveland U.S.A., arrived in this country on March 27th. He is primarily interested in visiting Electric Furnace Co., Ltd., who are the European agents and concessionaires for TOCCO equipment. During his visit, lasting some five weeks, Dr. Osborn will be visiting installations carried out by EFCO in this country and abroad. He will also be available to meet prospective purchasers of TOCCO and EFCO-TOCCO (British built) induction heat treatment equipment. A series of meetings is being arranged, details of which will be given later.

Tungsten Carbide Tool Reservicing

THE Wickman mobile demonstration unit will again tour industrial areas in Great Britain during the coming year to demonstrate tungsten carbide tool reservicing.

This follows the very successful tour which took place during 1952, and any organisations who were unable to secure a visit of the unit during that tour may be interested in having the dates on which the unit will be in various areas during the coming year. They are :—

April 13th	to May 3rd	.. Scotland and N. England Area
May 11th	to May 31st	.. Manchester Area
June 8th	June 28th	.. Leeds Area
July 6th	to July 26th	.. Birmingham Area
Aug. 17th	to Sept. 6th	.. Bristol Area
Sept. 14th	to Oct. 3rd	.. London Area
Oct. 12th	to Oct. 31st	.. Coventry Area

In addition to practical instruction in reservicing carbide tools, the personnel accompanying the unit will arrange lectures when required, which will be supported by 16-mm. sound films and film strips covering re-servicing and application. Applications for this service should be addressed to any Wickman branch office, or to Wickman, Ltd., Wimet Division, Torrington Avenue, Coventry.

B.I.C.C. Canadian Acquisition

BRITISH INSULATED CALLENDER'S CABLES LTD. announce that they have acquired, as from April 30th next, the cable and wire business of Phillips Electrical Works Ltd., Canada, and will, through a new Canadian Company which they are forming with the name of "Phillips Electrical Company (1953) Ltd.," carry on this business as a going concern at the existing Brockville (Ontario) and Montreal factories. The existing personnel engaged in the cable and wire business of the present Phillips Company will be retained.

Radio Control System for Magnesium Foundry

MESSRS. STERLING METALS, LTD., have placed, through the Vaughan Crane Co., Ltd., an order for one of the radio control systems developed by Heenan & Froude, Ltd., for the remote control of overhead cranes. This equipment will be used in a magnesium foundry at Nuneaton for emergency and remote control of a furnace crane in the event of melting ladle failure.

Tar Acids Sales

MONSANTO CHEMICALS, LTD., and The Midland Tar Distillers, Ltd., jointly announce that due to good progress with the building of a tar acids refinery at Four Ashes, near Wolverhampton, The Midland Tar Distillers will take over from Monsanto the selling and sales service of :—

(*a*) ortho-cresol and all grades of cresylic acid as from April 1st, 1953 ; and

(*b*) natural phenol on July 1st, 1953.

It will be recalled that in October 1951 it was announced by the two companies that The Midland Tar Distillers, Ltd., was building the refinery and would in due course take over from Monsanto the refining of its acids and the selling of the resultant products.

Personal News

H.R.H. THE DUKE OF EDINBURGH has graciously signified his willingness to become an honorary member of The Institute of Fuel.

MR. L. J. DAVIES has retired from the post of Assistant Managing Director of Richard Thomas & Baldwins, Ltd., on account of age. He will, however, remain on the Board of the Company. He is succeeded by MR. G. A. YOUNG, General Manager Ebbw Vale Section, who has also been appointed to the Board of The Steel Company of Wales, Ltd. MR. G. J. GILBERTSON has retired from the Board of Richard Thomas & Baldwins, Ltd., on the grounds of ill health.

MR. F. L. NOBES joined the Board of The Carborundum Company on January 7th. MR. S. G. BLAKE becomes a Director-Emeritus from the same date.

MR. J. F. B. JACKSON, who has been Director of Research of The British Steel Founders' Association since the formation of its Research and Development Division in 1949, has been appointed Director of the recently-formed British Steel Castings' Research Association.

MR. A. R. POWELL, Research Manager of Johnson, Matthey & Co., Ltd., has been elected a Fellow of the Royal Society.

SHEEPBRIDGE ENGINEERING, LTD., Chesterfield, announce that, following the transference of their Group Sales Office from London to Chesterfield, MR. M. M. HALLETT, formerly Research and Development Manager has been appointed Director of Sales, with the object of ensuring the highest level of technical service to customers.

MR. A. CORK has resigned his position as Foundry Metallurgist of the Wellworthy Piston Ring Co., Ltd., Ringstead, to join the technical staff of The British Electro Metallurgical Co., Ltd.

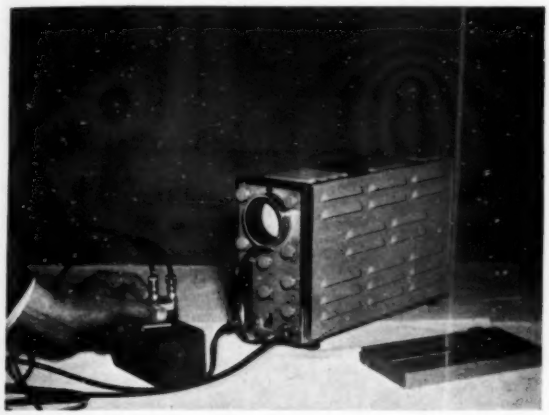
MR. N. V. CRABTREE has been appointed Manager for the Coated Abrasives Division of The Carborundum Co., Ltd., which is shortly to begin the manufacture of a broad line of surface-coated products in this country.

MR. H. D. ROBERTS, who has been Secretary of Air Control Installations, Ltd., since its inception in 1935, has been appointed to the Board.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

Miniature Ultrasonic Flaw Detector

THE various means of detecting flaws in metallic structures each have their own advantages and limitations, and it would be erroneous to assume that any one method would be the best in all circumstances. Although of comparatively recent development, the ultrasonic method has now firmly established itself in this field, and has found application in a variety of ways.



The method uses a cathode ray tube to measure the time taken for a pulse of ultrasonic energy to travel from a transmission probe and return to a reception probe. As the C.R.T. spot passes the zero mark on a scale, the ultrasonic energy pulse in the form of a narrow beam is directed into the specimen under test by means of the transmitting crystal mounted in an exploring probe. Energy reflected, for example by the boundary of the specimen, is picked up by the receiving crystal and causes a vertical deflection of the C.R.T. spot. The presence of a flaw is indicated by any deflection of the spot between the zero mark and the boundary echo. Its position can be deduced from the relative positions of the flaw echo and the boundary echo.

Kelvin & Hughes (Industrial), Ltd. have been closely concerned with the development of the method in this country, having designed a series of instruments for this purpose. The latest development, the Mark 5 Supersonic Flaw Detector is much smaller than previous models, having been designed for the inspection of welded pressure vessels where the equipment has to be passed through a manhole. It possesses the essential features of the Mark 4, the main difference being in the size of the cathode ray tube. Although the screen is smaller, the scale can be expanded so that the width of the screen represents only a small part of the total range, thus facilitating thickness measurement or the individual detection of closely grouped flaws. An edge-illuminated Perspex screen with an engraved scale facilitates photographic recording, for which a special camera can be provided. A very bright trace is achieved, even on the shortest range, which is adequate for daylight viewing.

The instrument, which uses the new lightweight leads, can be operated with the full range of Kelvin & Hughes probes. A special combined transceiver probe (shown in the illustration) provides many of the advantages of the dual probe system whilst allowing the ease of handling inherent in a single probe. The co-axial sockets are duplicated to allow for the use of special filters on a depth and thickness gauge.

The operating frequency is chosen to suit the type of material being tested and is selected by means of a switch. Frequencies available are: $\frac{5}{8}$, $1\frac{1}{4}$, $2\frac{1}{4}$, $2\frac{1}{2}$ and 5 Mc/s, intermediate frequencies being obtained, if required, by the use of plug-in filters. The range represented by full deflection of the time base can be varied from 2 in. to 12 ft. when using ordinary vertical probes: these distances are approximately halved when transverse wave probes are used.

The cathode ray tube and all valves used in this new equipment are easily obtained standard types, and the standard instrument operates from 200–250 V. 50 c/s. A.C. mains, other voltage ranges being supplied to special order.

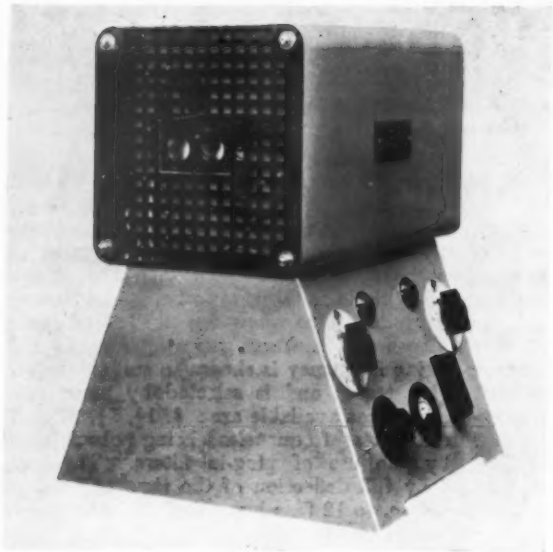
Kelvin & Hughes (Industrial), Ltd., 2, Caxton Street, London, S.W.1.

High Temperature Tube Furnace

THE standard Wild-Barfield tube muffles of the single and twin tube types have been in use for many years for analytical and laboratory applications. These muffles were designed to give a maximum operating temperature of 1,050° C. (1,922° F.), which temperature meets most normal requirements. There are occasions, however, when tube muffles capable of operating at temperatures up to 1,400° C. (2,552° F.) are required, and with this in mind, Wild-Barfield are manufacturing a new tube furnace, designated model CC22, the construction of which is such that the exothermic reaction of high alloy steels at the appropriate temperatures does not harm the furnace by excessive temperature on the elements.

As will be seen from the illustration the new furnace is designed for bench operation and is self-contained with built-in hand temperature control equipment and pilot lights. It is designed to take two standard combustion tubes $1\frac{3}{8}$ in. outside diameter. The heating chamber is 4 in. square and 6 in. heated length with well insulated vestibules at each end to give the greatest practicable uniformity of temperature. It is claimed that, over a length of 4 in. uniformity within ±10° C. (18° F.) at 1,390° C. (2,534° F.) is obtained, this being a uniformly heated length ample for normal carbon and sulphur determinations.

In addition to the insulated vestibules, there is a ventilated compartment at each end, housing the connections to the heating elements. It is recommended that the combustion tubes (not supplied with the furnace) should be 24 in. long to ensure that the ends are reasonably spaced from the furnace itself. The elements consist of silicon carbide rods, the life of which is extended



by means of the Wild-Barfield patented control. Additionally, a tapped transformer is fitted in the base and a tap changing switch, together with the ageing control switch and pilot lights, are easily accessible on one face of the plinth.

The furnace, rated at 1·75 kW, is suitable for operation on 200/250 volt A.C. supplies, and is supplied ready for installation, a 6 ft. length of 3-core cable being provided for connection to the electricity supply. Illustrated literature and further details are available on request to the manufacturers.

Wild-Barfield Electric Furnaces, Ltd., Watford By-Pass Watford, Herts.

Electro-Hydraulic Flanging Press

An electro-hydraulic plate flanging and folding press of the latest design is announced by Hugh Smith and Co. (Possil) Ltd. The press is fitted with a Towler high-speed pump, making it self-contained, and has been designed to do all work normally carried out on a mechanical press brake, but the advantages of the hydraulic machine are: (1) the maximum pressure is available throughout a 12-in. stroke; (2) the press can be accurately and sensitively controlled and reversed in any position; (3) the hydraulic drive eliminates any danger of breakage due to overloading; (4) the pressure can be maintained on the job for long periods.

This latest Hugh Smith machine features exceptionally long guides and, provided with adequate lubrication, will ensure accuracy and long life. The press is robustly built, and is designed for continuous duty under arduous workshop conditions. The pressure gauge reads the exact tonnage required for any particular job and this is useful in estimating the power necessary for future jobs. The moving beam has the normal press brake type of gripper bar and can therefore take a wide range of tools. The table is tee-slotted to receive a wide range of blocks or dies.

The use of the Towler Electraulic pump, which has proved to be exceptionally reliable, coupled with the absence of mechanical moving parts, is claimed to have resulted in a machine of outstanding performance, requiring the minimum of maintenance.

These 300-ton presses are being produced in 8 ft., 10 ft. and 12 ft. lengths and, as continuous production is being maintained, it is understood that comparatively early delivery is offered.

Hugh Smith and Co. (Possil) Ltd., Possil Engine Works, Glasgow, N.

Flame Failure Control

A photo-electric protective device which is sensitive to the flame of automatic and semi-automatic oil burners, is being produced by The Rheostatic Company Ltd. The application of a photo-electric cell to oil burner flames is not new, but in developing this Satchwell type the company had in mind the necessity for producing a device which will prevent operation of the oil burner, not only on non-establishment of the flame during starting or failure of the flame during running; but, in addition, the oil burner will be stopped should either the photo-electric cell or the amplifying valve be broken; if one of the external electrical connections to the device is broken or otherwise open circuited; if a path of low resistance is created between the terminals of the photo-electric cell caused, for instance, by operation in an exceedingly dirty boiler house; or if an electrical short circuit develops across the terminals of the photo-electric cell by damage or otherwise. As far as possible it is ensured that any abnormal condition arising in connection with the device or its associated equipment will cause the oil burner to be stopped.

The Satchwell PER photo-electric device is intended to supplement the "CM" and "B" flue thermostat control and has particular application to those installations where it is necessary to have a device which will react to the flame itself. It frequently happens that more than one oil burner is feeding one flue and in such cases it is clearly unsuitable to have a flame failure device which responds only to flue temperature. Other applications are those where it is difficult to find a position in the flue where a thermostat can be installed satisfactorily.

The Rheostatic Company Limited, Slough, Bucks.

Refractory Strainer Cores

Strainer cores, either of oil-sand or metal, are widely used in the foundry industry to control the flow of metal into the moulds, and to reduce the danger of entrapped non-metallic material in the castings. Strainer cores made from ceramic materials have valuable advantages over their conventional counterparts. They are unaffected by molten metals; are not prone to cracking, erosion or collapse during pouring of the metal; and, because they are pre-fired, do not "gas" the metal. In addition, as compared with oil-sand strainer cores, which are, of course, made in the foundry, the use of the ceramic article releases labour and other productive resources for more direct participation in the production effort. Field trials have already established the effectiveness of this type of strainer core. They are supplied in cartons of 100, in which they may be stored indefinitely without suffering deterioration.

Messrs. Coupe & Tidman, Ltd., Treforest Trading Estate, Swansea, Glam.

METALLURGICAL DIGEST

How to Fabricate 17% Chromium Stainless Steel

By Richard E. Paret

LONG used for many applications, straight 17% chromium stainless steel is gradually filling gaps caused by restrictions on nickel-bearing stainless steels. To apply it successfully however, it is necessary to be familiar with its fabricating properties. Using straight chromium steels to replace nickel-bearing steels requires analysis of production methods, as well as consideration of service needs. The 17% chromium stainless steel has its own properties and its own fabrication techniques. In the annealed condition, the elongation of 18–8 stainless steel is almost twice that of the 17% chromium steel, whilst the spread between tensile and yield strengths is smaller in the latter, and the range of plastic deformation is reduced.

Drawing.—While the 17% chromium steel draws into deep, intricate shapes as well as the best quality carbon steel, it does not have the outstanding drawing properties of the 18–8 stainless steel. This nickel-bearing steel can be reduced up to 35 to 40% in one draw, whilst the straight chromium steel reduces 20 to 25% on the first draw, and 15% on subsequent operations. Cracks in the side walls, or a "ropy" surface texture, may result from too severe reductions. Annealing between draws, when required with the straight chromium steel, is carried out at 1,400° to 1,500° F., never above 1,550° F. Parts can be cooled rapidly. Drawing the straight chromium steel is easier if the metal is warmed before working, and some manufacturers suggest dipping blanks in boiling water. In any case, cold stock should be brought up to room temperature before drawing.

Blank size and shape, temper and finish are important in drawing. With the straight chromium stainless steels, it may be necessary to use larger blanks than with the 18–8 type, as the former tends to stretch locally. Because of the directional properties of the chromium steel, the flange on round parts sometimes draws into "ears," and the flange diameter must be large enough to retain a flange around the whole finished shell. The right die and draw ring are also important with the straight chromium stainless steels. The clearances between the die and the punch are about the same as for mild steel—somewhat less than those allowed for 18–8 stainless. Radii should be more liberal than, sometimes even double, those used for 18–8, and dies should be designed for a spring-back allowance two to three times that specified for mild steel. Solid dies of non-deforming, high-carbon, high-chromium tool steel are most satisfactory. Ordinary cast-iron dies wear rapidly and are suitable only for short runs. Chromium- and nickel-alloy cast irons are good, however, and hard cast bronze is suggested for draw rings, as it has less tendency to gall or seize the metal. The radius of the draw ring should be larger than with mild steel, and the ring should be well polished and buffed. Oil stones and kerosene, rather than abrasive cloth or similar materials, should be used to remove metal adhering to the draw ring or pressure pad after drawing.

A lubricant of high film strength and adhesive quality should be applied before the blank is put in the die. Most good stainless drawing lubricants contain either an oil or animal fat base and are highly sulphurised; they can be diluted to the proper consistency for the particular operation. A light, shallow draw calls for a water-soluble lubricant, whilst a heavy draw requires an oil soluble material. Latex or plastic-based coatings sometimes applied to the blank protect the finish and act as a lubricant.

Generally, the straight chromium stainless steels require no more rugged equipment or press power than the 18–8 type. Pressure pads should be more carefully adjusted, however, to exert enough force on the blank to prevent wrinkling, but not so much as to prevent flow. This usually requires a double acting press. Forming tools, such as brakes and presses, rated at a definite capacity for mild steels, are usually suitable for stainless steels of about one half the thickness.

Spinning.—The straight chromium stainless steels do not work harden as fast as the 18–8 type and this is an advantage in spinning, as they can be spun to rough shape, then drawn. Television viewing tubes are made in this way from a modified straight chromium stainless steel having a coefficient of expansion close to that of glass. Ordinary cast-iron spinning tools are satisfactory, but a nickel-chromium iron, with a composition of 3% carbon, 2·5–3% nickel, 0·75–1% chromium, and 1·20–1·50% silicon, treated for maximum hardness, is recommended. The tool should be similar to that used for copper, but somewhat flatter with a greater bearing surface; roller tools are generally more satisfactory. During spinning, a lubricant must be used generously and completely removed before annealing. Yellow or naphtha soap is satisfactory, and it is sometimes advisable to use a heavy polishing tallow in conjunction with the soap. Heavier equipment is required to spin the straight chromium stainless steels than ordinary steels and spindle speeds must be reduced to approximately two-thirds those used for mild steels. As a rule, they can be spun about one-third as much as mild steel before annealing is required.

Blanking.—There is no problem in shearing or blanking in converting from the 18–8 type to the straight chromium steels. Both types require smaller clearances than ordinary steels, and blades and dies must be closely adjusted and as sharp as possible. There is one advantage in using the straight chromium steels, they break after 50 to 75% of their thickness is cut in shearing; the 18–8 type must be cut almost completely through. For annealed stainless, the capacity of a shear will be 50–75% of the thickness it can handle in mild steel, and, as a rule, a shear should have a capacity in mild steel four or five gauges heavier than the stainless being sheared. Ordinarily, stainless steels require about twice the power that mild steel does.

Bending.—The 17% chromium stainless steels show directional properties according to the direction in which the sheet is rolled, and severe bends should be made across the rolling direction. If possible radii twice as large as those allowable with 18–8 stainless should be used. If the bend is parallel to the rolling direction, the inside radius

From *Materials and Methods*, 1952, November, 100-104.

should be at least one metal thickness. On material heavier than 18 gauge, 180° bends require a radius of at least two metal thicknesses if the bend is across the rolling direction and at least four if it is parallel to it.

Machining.—The 17% chromium stainless steel is easier to machine than the 18–8 type, but there is a tendency to gall or build up on the cutting edges of the tool. This will cause high tool pressures, high temperatures at the cutting point, and a torn finish. The chips produced are brittle and stringy. Galling can be reduced greatly by using tools sharply ground to a fine finish. A slight variation of the straight chromium stainless steel greatly improves its machining qualities; this composition can be annealed to a hardness of about 170 Brinell, but the best machinability is obtained at approximately 228 Brinell, when the chips are short and brittle, and chip control is relatively easy.

Welding.—Straight 17% chromium steel welded joints may be brittle at room temperatures because of grain growth caused by high welding temperatures. Weld embrittlement is also caused by the formation of brittle martensite around the grain boundaries at high temperatures. Annealing at 1,400° to 1,500° F. will temper the martensite and partly alleviate the brittle condition, but it will not correct grain growth. The addition of titanium to the composition inhibits the formation of martensite and, with this composition, welds are fairly ductile in both the as-welded and annealed conditions.

Plastic Stress-Strain Relations of Alcoa 14S-T6 for Variable Biaxial Stress Ratios

By J. Marin, L. W. Hu and J. F. Hamburg

THE plastic stress-strain relations in this investigation were obtained for an aluminium alloy designated as Alcoa 14S–T6. These stress-strain relations were found for biaxial tensile stresses produced by subjecting a thin-walled tubular specimen to axial tension and internal pressure.

Three types of biaxial stress tests were conducted in this study—constant stress ratio tests and two types of variable stress ratio tests. In the constant stress ratio tests, plastic stress-strain relations were obtained for conditions where the ratio of the axial to the lateral stress was maintained essentially constant for each test. These constant stress ratio tests were made to provide control data and to determine the influence of the biaxial stresses on the ductility, yield strength and fracture strength. The constant stress ratio tests showed that the biaxial yield strength values are in approximate agreement with the distortion energy theory. The biaxial fracture strength, however, is in best agreement with the maximum stress theory. A comparison of the true biaxial plastic stress-strain relations for various principal stress ratios with values predicted by either the flow or deformation-type theory shows an approximate agreement between test results and theory. The ductility under biaxial stress conditions was found to decrease with increase in the biaxiality of the stresses. The theoretical values of ductility based upon the significant strain and the deformation theory agree approximately with the actual ductility values.

The main object of this study is not to report on the foregoing constant stress ratio tests but rather to determine the validity of the flow-type theory in predicting plastic stress-strain relations under combined stresses. For this purpose, two types of variable stress ratio tests were conducted. In one type of variable stress ratio test, a stress was applied in the axial or lateral direction to a selected plastic strain value, followed by a stress in the other direction perpendicular to the first direction of the stressing. In a second type of variable stress ratio test, a stress in one direction was followed by a stress in the right-angled direction and then by a stress in the first direction. The results of these tests indicate that the flow theory gives a good approximation to the experimental results. Both types of variable stress ratio tests show that the path of loading has little effect on the true fracture strength and that the fracture strength is approximately defined by the maximum stress theory. The variable stress ratio tests, using different paths of loading to arrive at the same state of stress, give widely different values of strains. This lends support to the flow rather than the deformation or slip types of theory since the latter theories require these strains to be the same.

Paper presented at the Thirty-fourth Annual Convention of the American Society for Metals, Philadelphia, October 20th–24th, 1952. Preprint No. 24, 22 pp., 1952.

Chromium Carbide Meets Many Industrial Needs

By J. D. Kennedy

THE first of a series of cemented chromium carbides has been made available by the Carboloy Department of General Electric Company. This new metal is composed of 83% chromium carbide, 2% tungsten carbide and 15% nickel. It has a high resistance to both corrosion and erosion, and also good abrasion resistance. Made by the powder metallurgy process, this metal is light in weight, has a coefficient of thermal expansion approximately the same as steel, is completely non-magnetic, and has very good resistance to high-temperature oxidation.

Among its outstanding physical properties are its density, which is about half that of tungsten carbide, and its coefficient of thermal expansion, which is about half that of steel. It is a hard, strong metal and resists abrasion much better than hardened steel.

Salt spray tests reveal that chromium carbides retain their metallic lustre after being subjected to a 30% salt spray for 750 hours. When subjected to sulphuric acid corrosion tests, they show 30 times the resistance of 18/8 stainless steels and three times the resistance of conventional carbides. Their resistance to nitric acid is eight times that of other carbides and twice that of 18-8 stainless steel. They are also inert when exposed to citric or lactic acids.

Chromium carbides resist oxidation at all temperatures up to 1,832° F. When subjected to a temperature of 1,850° F. for 24 hours, samples are only slightly discoloured, while simultaneously exposed samples of stainless steel and tungsten carbide have completely disintegrated. Steam erosion tests show a resistance for chromium carbides about 50 times that of conventional carbides.

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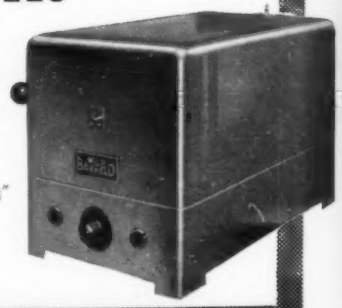
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Full details of these muffles will gladly be supplied.



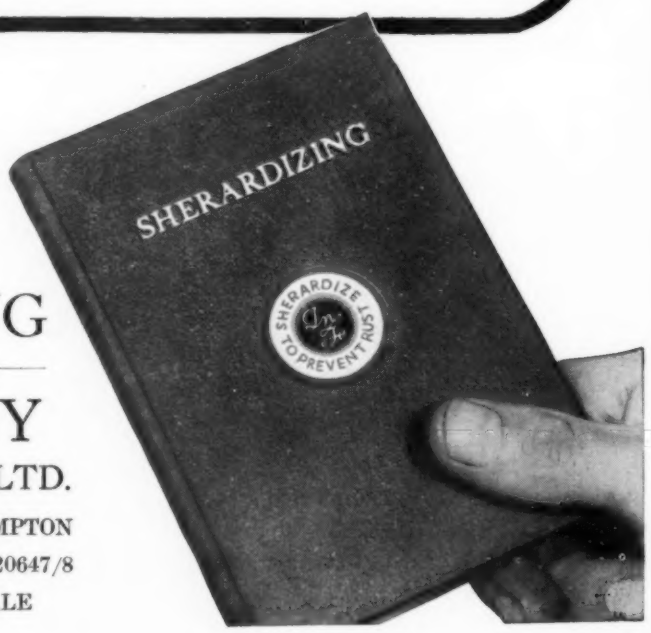
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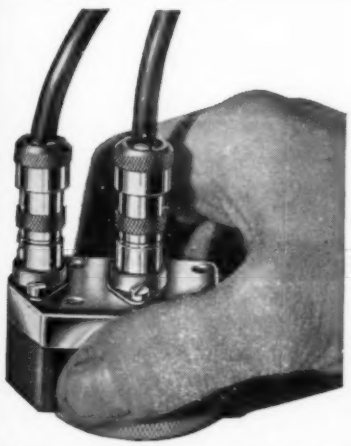
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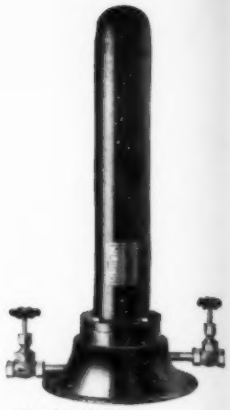
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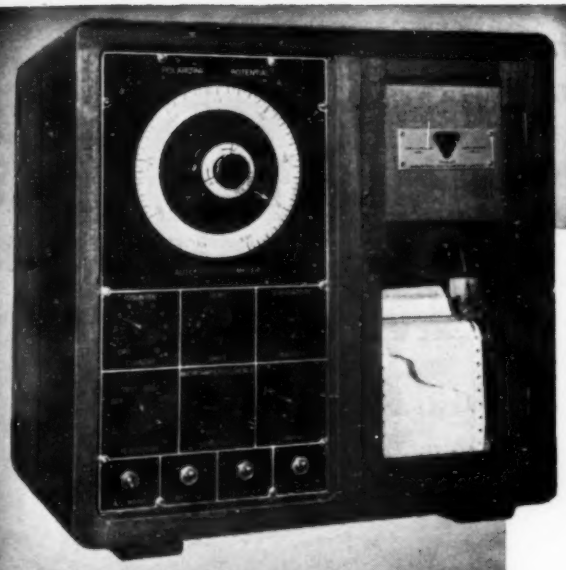
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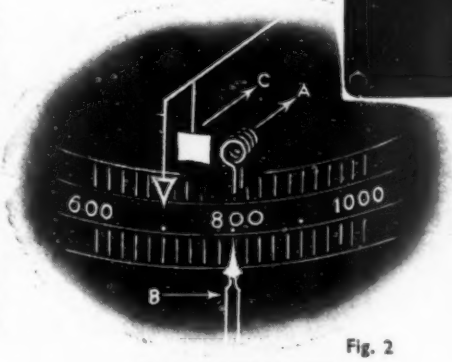


Fig. 2

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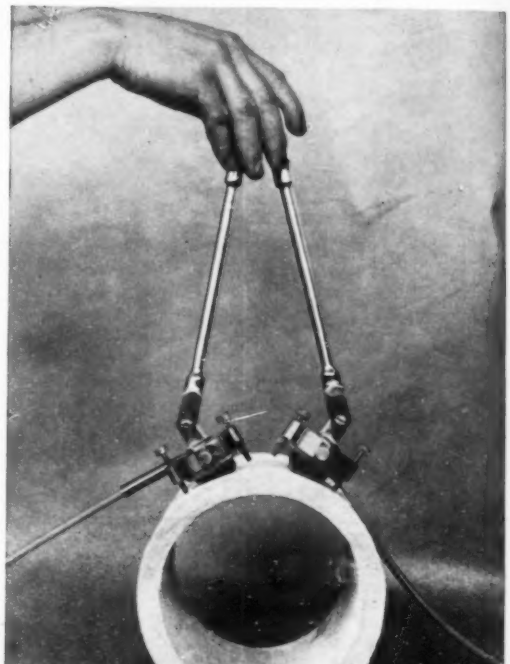
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Microradiography of Permanent Magnet Alloys

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X-ray microradiography technique has been applied to a study of the Alcomax-type of anisotropic permanent magnet alloys. The five types of segregate found can be explained in terms of phases known to occur in the Fe-Ni-Al system. Micro crack formation can also be studied by the use of this method.

THE new experimental technique of X-ray microradiography has already found useful applications in several fields of metallurgy and mineralogy for the study of the segregation of elements in certain areas of a matrix[1, 2]. In permanent magnet alloys, the presence or absence of such segregations is of especial interest, as they may influence the magnetic properties to a considerable extent: this applies particularly to the modern Alnico and the anisotropic Alcomax types of alloy. Although optical microscopy has been used extensively, for instance in Bradley's work[3] on the Fe-Ni-Al system fundamental to these alloys, and although Oliver and Goldschmidt[4] and, more recently, Geissler[5] have studied the structure of Alcomax by X-ray diffraction, microradiography does not so far appear to have been suggested as a method of investigation, probably partly because of the difficulty of preparing the thin sections necessary.

The present paper reports briefly certain observations made on these alloys by the use of the microradiographic technique, attention being directed to the principles involved rather than to the particular results obtained.

Experimental Technique

Thin sections of Alcomax were prepared by first rough-grinding plates of the alloy to a thickness of approximately 0·030 in., and subsequently mounting the samples on a magnetic chuck and cautiously continuing to grind with a fine wheel, using copious quantities of coolant, until a thickness of 0·002 in. was attained. The small foils, although frail and brittle, were sufficiently robust to cohere and to be handled.

For microradiography, the Alcomax foils were mounted in contact with the emulsion of Kodak High Resolution plates, which were subsequently examined by the microscope in the usual way. The radiation used was generally cobalt K_α, but for some of the experiments chromium, copper or tungsten targets were also used. The plates were exposed for 25 minutes at 30 kV and 10mA.

The alloy samples examined had the following compositions (weight %):

Alcomax (A)

Co	Ni	Cu	Al	Nb	Ti	Mn	C	Fe
21·3	11·6	4·6	8·58	—	—	—	0·04	Remainder

Alcomax (B)

Co	Ni	Cu	Al	Nb	Ti	Mn	C	Fe
24·8	13·3	4·2	8·35	0·72	—	0·06	0·03	Remainder

The samples were examined after a variety of heat treatments had been applied to them, namely (*a*) as cast; (*b*) as hardened; (*c*) as hardened and tempered; (*d*) as hardened with an external magnetic field applied during cooling; and (*e*) as (*d*), followed by tempering. The specific treatments applied in each case are not, however, considered in this article, attention being drawn rather to the radiographic effects observed.

Results

A selection of typical microradiographs obtained during the course of this work is shown in the accompanying illustrations. Several types of segregation phenomena were noted as well as the formation of microcracks along the grain boundaries. The evidence concerning the cracking will be considered first.

Crack Formation

The formation of fine cracks in Alcomax is shown in great detail by microradiography, as may be seen from Figs. 1 to 8.* While such cracks are visible in normal (optical) photomicrographs, for example Fig. 9, as fine surface hair-lines, X-rays give a stereoscopic view, revealing cracks at successive depths below the surface, as well as indicating their width and angle. It is found that fissures appear either in sets of several approximately parallel ones, or in seemingly interlacing strands of a number of single lines; this multiplicity and view in depth is, of course, not visible under the microscope. The cracks tend to be intercrystalline, and clearly delineate the grain-boundaries (see, for instance, Fig.1); the single crystals thus separated by the cracks are

1 Betteridge, W., and Sharpe, R. S., *Jnl. Iron and Steel Inst.*, 1948, **158**, 185.
2 Cohen, E., *Metallurgia*, 1950, **41**, 2.
3 Bradley, A. J., *Jnl. Iron and Steel Inst.*, 1949, **163**, 19, and 1951, **168**, 233.
4 Oliver, D. A., and Goldschmidt, H. J., E.R.A. Special Report 1947, No. NT/41.
5 Geissler, A. H., *Trans. A.S.M.*, 1951, **43**, 70.

* All microradiographs reduced slightly in reproduction.

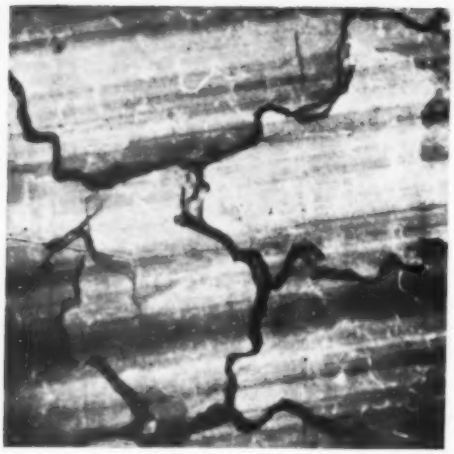


Fig. 1.

Fig. 1.—Type I segregates. ×80

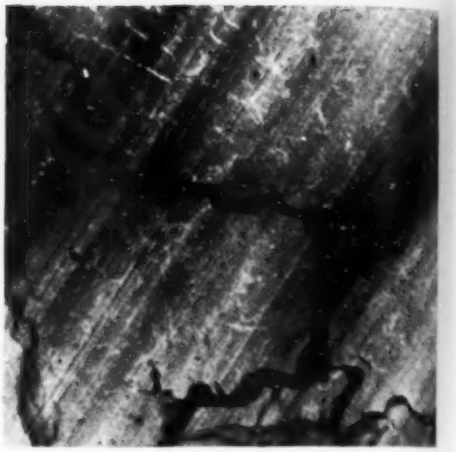


Fig. 2.

Fig. 2.—Type I segregates. ×80



Fig. 3.

Fig. 3.—Type I segregates. Note discontinuity at crack. ×80

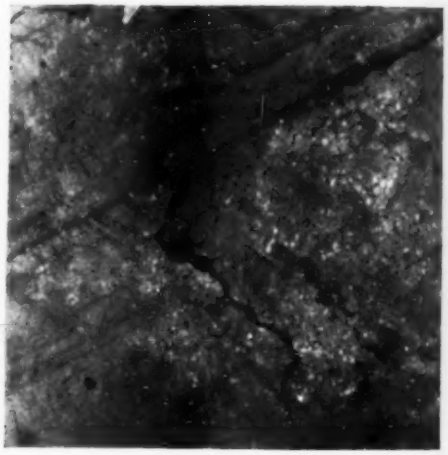


Fig. 4.

Fig. 4.—Types II and IV segregates. ×80

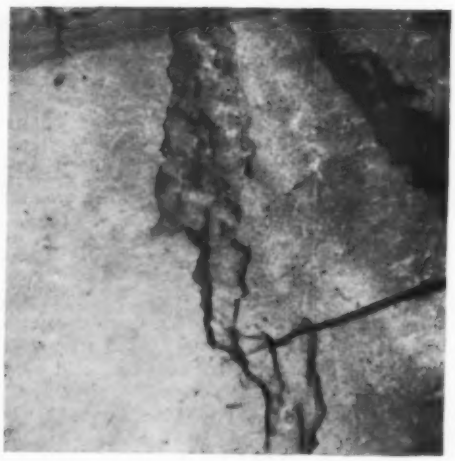


Fig. 5.

Fig. 5.—Types I and IV segregates. ×80



Fig. 6.

Fig. 6.—Crack formation. ×80



Fig. 7.

Fig. 7.—Crack formation. ×80

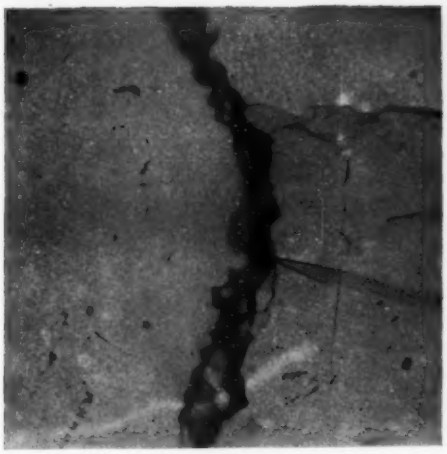


Fig. 8.

Fig. 8.—Type IV segregates. ×80

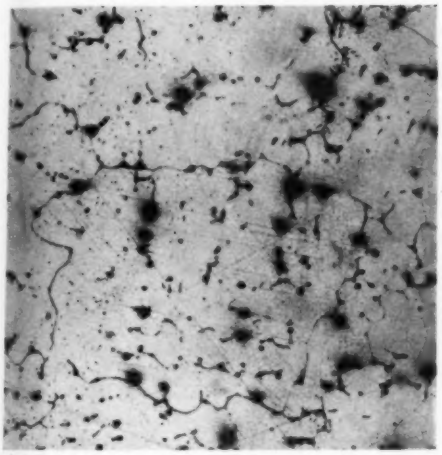


Fig. 9.

Fig. 9. — Photomicrograph of Alcomax. ×80

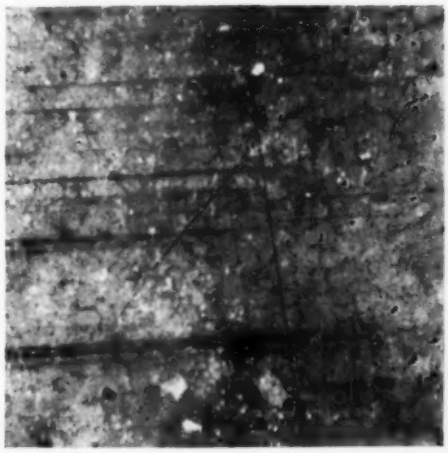


Fig. 10.

Fig. 10.—Types II and IV segregates. ×80

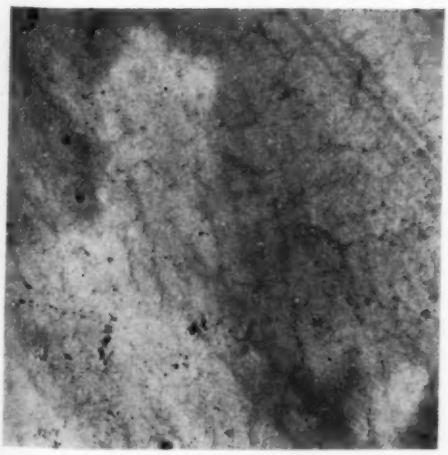


Fig. 11.

Fig. 11.—Types II and V segregates. ×80

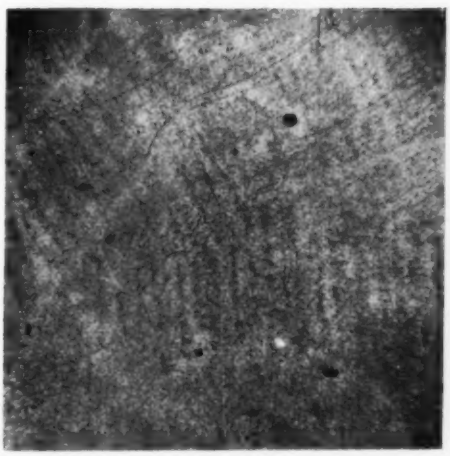


Fig. 12.

Fig. 12.—Type III segregates. ×80

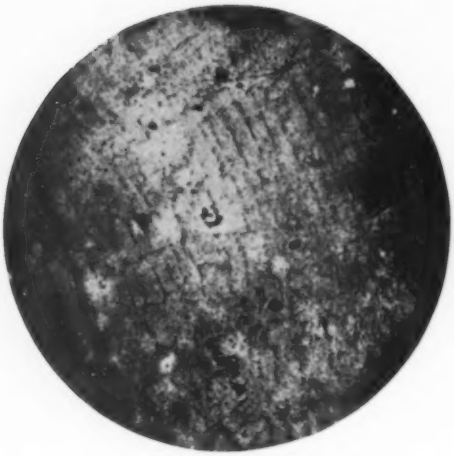


Fig. 13 (top left).—Type III segregates. ×50



Fig. 14 (top right).—Type III segregates (note break) (tungsten radiation) ×50

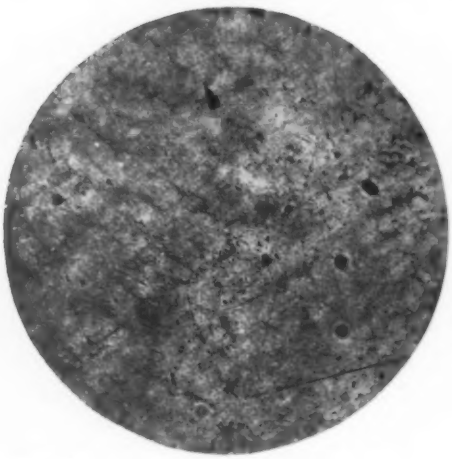


Fig. 15 (bottom left).—Type II segregates (chromium radiation). ×50



Fig. 16 (bottom right).—Types II and V segregates. ×50

further characterised as such by their distinctive internal markings, such as the vein-pattern produced by segregates and unique to each grain (see below). There appears to be a definite correlation between crack-formation and the direction of segregates: the cracks tend to form roughly parallel or normal to the lamellar segregates within an adjoining grain, while it may also be seen that cracks sharply change their direction where they meet such lamellae. The multiple strands of fissures (examples of which are shown in several pictures, perhaps best in Fig. 7) would appear to be caused by sheet-like strata of single crystals at successive depths. In the direction normal or near-normal to the surface of the sample, the cracks form a series of steps, each step being of the height of a single crystal; the angle of the steps with the vertical direction varies, as shown by varying photographic densities and flexures along any one crack.

Intracrystalline Segregates

The types of internal segregates visible on the Alcomax microradiographs may be classified as follows (using cobalt K_α radiation):

I short white bands, giving a white "vein-pattern" (*cf.* Figs. 1, 2, 3, 5).

II short black bands, giving a black "vein-pattern" (*cf.* Figs. 4, 10, 11, 15, 16).

III black linear network, "street-plan" like (*cf.* Figs. 12, 13, 14).

IV clusters of white spots, irregularly distributed (*cf.* Figs. 4, 5, 8, 10).

V difference in shade of different areas of background (*cf.* Figs. 11 and 16).

Type I Segregates change in orientation and pattern from one crystal to the next. They tend to form a systematic array of near-parallel broken lines; each individual shape corresponds to a short corrugated platelet of approximate mean length and width 0·01 cm., and approximate thickness 0·0001 cm. (1μ).

While in some grains the lines form an essentially parallel system, in others they show random orientation, while yet further crystals are intermediate in showing a lesser but marked trend to uni-directionality; each single line meanders to a varying extent, while the average direction of a given set tends to be parallel.

Type II Segregates form a similar vein-like pattern, but this time showing up black instead of white; also the continuous linear units tend to be longer than the white ones (0·02 to 0·03 cm., instead of 0·01 cm.), and are twice or three times as thick.

Type III Segregates form a highly regular network pattern of straight black lines. The black lamellae are approximately 0·0002 cm. wide, 0·01 to 0·03 cm.

long, and approximately 0·003 cm. distant from each other. It may be seen, for instance in Fig. 14, that abrupt breaks occur in this cellular system at crystal-boundaries, but there exist also more gradual changes in direction within what is presumed to be a single crystal : see Fig. 12 and 13, where a star-like swing of the system through an angle of about 10° may be observed.

These type III segregates are probably identical with type II, but represent a different cross-section through the same lamellae, showing that in space we are dealing with a system of sheets, linear and parallel in one direction, somewhat curved and branched in another (*cf.* Figs. 14 and 15).

Type IV Segregates are of an entirely different character. They consist of numerous white spots, aggregating in irregular clusters or, in some cases, occurring individually and in isolation. They correspond to small spheroidal globules of diameter 0·001 cm. and less, and it is noteworthy that the background upon which the larger globules aggregate is also lighter than that of the surrounding field, indicating that a multitude of similar but smaller particles cluster within the same area, though they remain unresolved rather in the manner of "stellar nebulae." Whether or not they actually merge cannot be said without much higher magnification.

Type V Segregates are represented by total areas of the microradiograph appearing lighter than adjacent areas ; these do not correspond to separate crystals, but to composition gradations within single crystals, as it may be observed that, for instance, the type II segregates cut across the boundaries between the type V ones ; a feature, incidentally, which may be taken as a useful criterion for defining single crystals within the polycrystalline mass.

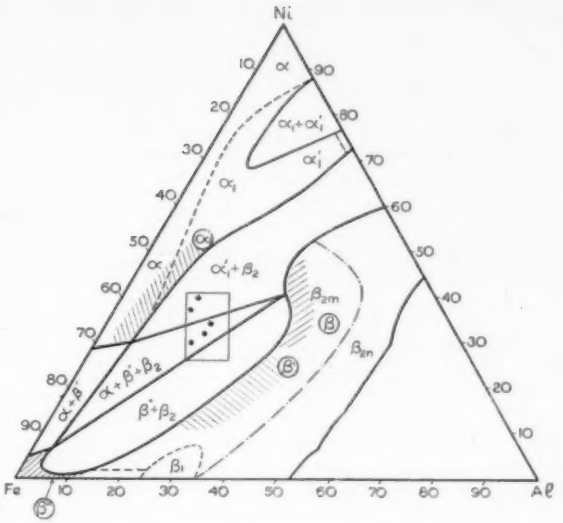
Identification of Segregates and Discussion

It is possible to correlate the chief types of segregate with the elements present in the alloy, and, furthermore, broadly to interpret them in phase-diagram terms. The linear absorption coefficients for the metals relevant to the Alnico-Alcomax types alloy are as shown in Table I.

TABLE I.—LINEAR ABSORPTION COEFFICIENTS OF ELEMENTS IN ALCOMAX TYPE ALLOYS.

Absorbing Element	Radiation (K_α)		
	Cr	Co	Cu
Al	402	200	131
Ti	2,665	1,350	902
Fe	902	470	2,550
Co	1,100	570	3,100
Ni	1,290	650	438
Cu	1,370	720	470
Nb	3,830	1,900 (approx.)	1,300

The phase-constitution of Alcomax has been investigatedby X-ray diffraction[4] : reference may be made to the original paper for details, but the essential result, as far as is relevant here, is that, under varying conditions of heat-treatment, three body-centred cubic phases and two face-centred cubic phases are liable to appear. Furthermore, a number of intermediate stages of precipitation may occur, corresponding to a tetragonal distortion of the unit cell, and to conditions in which a single-phase is still essentially maintained, with incipient precipitation occurring in the form of lamellar segregates within the parent-lattice.



Dotted lines indicate superlattice boundaries and chain dotted lines magnetic boundaries.

- α face-centred cubic.
- α_1 α_1' superlattice like Ni_3Al.
- β body-centred cubic.
- β_1 superlattice like Fe_3Al.
- β_2 superlattice like FeAl or NiAl.
- m magnetic alloys.
- n non-magnetic alloys.

The areas of the present α β, β' and β'' phases are indicated by shading, whilst the rectangle covers an area of typical Alcomax compositions, copper and cobalt being classed as nickel.

Fig. 17.—The Fe-Ni-Al system for slowly cooled alloys according to Bradley and Taylor[6].

The metallurgical relations may best be expressed in terms of Bradley and Taylor's Fe-Ni-Al diagram[6] shown in Fig. 17, which fundamentally still applies, in spite of modifications due to the presence of cobalt and copper. Within the extensive body-centred solid solution field (β) a miscibility gap opens out at low temperatures, with the result that the parent β-phase, which is situated near the NiAl end, precipitates the iron-richer and aluminium-poorer β' and β'' phases of compositions corresponding to various points along the phase-boundary of the duplex miscibility gap. Furthermore, it is possible, by only minor differences in quenching, annealing and tempering temperatures and times, to produce the face-centred cubic α-phases which, when fully precipitated, are low in aluminium, ranging along the Fe-Ni side. α-phase formation can occur spontaneously from β, in which case the mechanism is such that aluminium-impoverished regions will already exist within the parent body-centred lattice, preparatory to α segregation. The α-phase observed is able also to vary in composition, principally nickel content.

It is fully consistent with the absorption-coefficients of the elements concerned, if we interpret the above types of segregate observed on the microradiographs in terms of the present β, β', β'' and α-phases. Assuming we are dealing with the ternary Fe-Ni-Al system only, the linear absorption coefficients for representative compositions may be calculated, for cobalt-radiation, as follows :—

6 Bradley, A. J., and Taylor, A., *Proc. Roy. Soc.*, 1938, 166A, 353.

Absorbing Composition	Absorption Coefficient μ
Ni Al	425
$Fe_2Ni_4Al_3$	461
Fe_2Ni Al	448
Fe_7Ni Al_2	434
Fe_6Ni_2Al	497
Fe_3Ni	516
$Fe_{36}Ni$ Al	467

Although the absolute values of absorption do not differ greatly, the difference is quite sufficient to explain the photographic contrast observed.

Thus, it would appear reasonable to conclude that the β-matrix phase of $\mu \simeq 450$ (the figures are only illustrative) precipitates, firstly, segregates of $\mu \simeq 430$ (darker bands, types II and III), corresponding to the aluminium-richer β'-phase, secondly, segregates of $\mu \simeq 460/470$, corresponding to the iron-rich β''-phase, and thirdly, segregates of $\mu \simeq 490$ and higher, corresponding to the Fe-Ni rich α-phase, the latter two showing up as the white veins and globules (types I and IV). The additional presence of cobalt and copper will introduce a quantitative alteration of the absolute values of these coefficients, but does not affect the essential validity of the above interpretation. The test of changing the radiations to copper and chromium K_α fully supports this interpretation ; the same segregates remain visible with the three radiations, indicating the aluminium content as a major variable. Copper-radiation (*cf.* Table I) shows the white iron-rich β'' and α-segregates with an increased degree of contrast, the difference in nickel content being insufficient to effect a reversal of shade with the copper wavelength, and in any case being counteracted by the cobalt largely substituting it.

In some respects there exist, however, certain variations in shape and size of a given segregate with different radiations, suggesting that the atoms concerned do not segregate homogeneously, but that there is, within and around each segregate, a local gradation in the density of elements (Fe, Ni, Co, Cu, Al) ; this " secondary coagulation " still permits the segregate to be regarded as single phase, but as representing a range of fluctuations in composition. In terms of X-ray diffraction, this would show itself as diffuse lines, which are indeed frequently observed, and which are thus not altogether due to internal strains, but may also be due to heterogeneity in composition. (It may be remarked that in cases of doubt whether diffuse lines are due to strains or composition variations, micro-radiography may often prove a useful auxiliary tool to X-ray diffraction in alloy work generally).

The type V segregates (total areas) are explained by essentially similar differences in constitution ; the composition within the lighter areas is, however, isostructural to that in the darker ones (viz. corresponding to an adjoining part of the same β-solution field). The two adjoining compositions are not sufficiently divergent to prevent both from occurring within the same crystal, so that it is observed that the earlier types of segregates (veins, etc.) are still able to cross the boundary between them.

Niobium, though possibly contributing to the white segregates to some extent, certainly cannot in itself explain them, particularly as they occur in both Alcomax B (0·7% Nb) and Alcomax A (no Nb). (It is, however, suggested, that a further fruitful line of research would be a study of the specific effect of titanium, niobium and similar additions by micro-radiography).

The physical difference between types I and IV segregates (viz. the vein structure and the globules) is probably that the globules are due to lack of homogeneity in the alloy as melted, and could be removed by a high temperature treatment, whereas the veins are caused by genuine lattice precipitation.

The observation, within the matrix, of white or black " corrugated " lamellae consisting of various phases other than the matrix (α, β', β'') is well corroborated by earlier diffraction results[4], which showed that small rods of Alcomax cut from the anisotropic bulk alloy in different directions, and used as Debye-Scherrer samples, appeared to contain different proportions of β- and α-phases, depending on whether the section had been made predominantly along or across the lamellar segregates of α-phase.

Conclusions

Several types of segregate have been observed in Alcomax alloys by the technique of X-ray micro-radiography, the segregates varying in character and orientation from crystal to crystal, and with heat-treatment. The segregates can be explained in terms of phase-constitution and precipitation effects known in these alloys from X-ray diffraction results. Their distribution will very probably have a fundamental bearing on the magnetic properties of the alloy, so that the effect of such external measures as the application of a magnetic field during cooling or the growth of columnar crystals from the melt, will at least partly consist in controlling and modifying these segregates and their degree of anisotropy.

Crack-formation in these (and other alloys) can also be usefully studied by the present technique ; a stereoscopic view is obtained of the cracks, which tend to be intercrystalline, and to be related to the intracrystalline segregates in direction.

It is suggested that this work may fruitfully be followed up by a broader research programme designed to discover the relationship between these segregates and the magnetic properties, varied composition and heat-treatment.

Acknowledgments

The writer wishes to thank Mr. D. A. Oliver, Director of Research, the B.S.A. Group of Companies, for his interest and encouragement. He is also indebted to Miss P. Walton for valuable assistance.

Laboratory Equipment Exhibition

An exhibition of laboratory equipment, organised by the Sheffield Section of the National Trades Technical Societies, will be held at the Cutlers' Hall, Sheffield, on May 18th–20th. The exhibition will include demonstrations of electronics, pyrometry, furnaces, glass technology, microscopy, etc.

Change of Address

Metro-Cutanit, Ltd., announce the removal of their administrative and sales office from 160 Piccadilly, W.1, to Grappenhall, Warrington, Lancashire. The new offices are located in the same buildings as the Company's Grappenhall factory, and many advantages in efficiency and service will result from this move.